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SOLID WASTE MANAGEMENT IN RESIDENTIAL COMPLEXES

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1971

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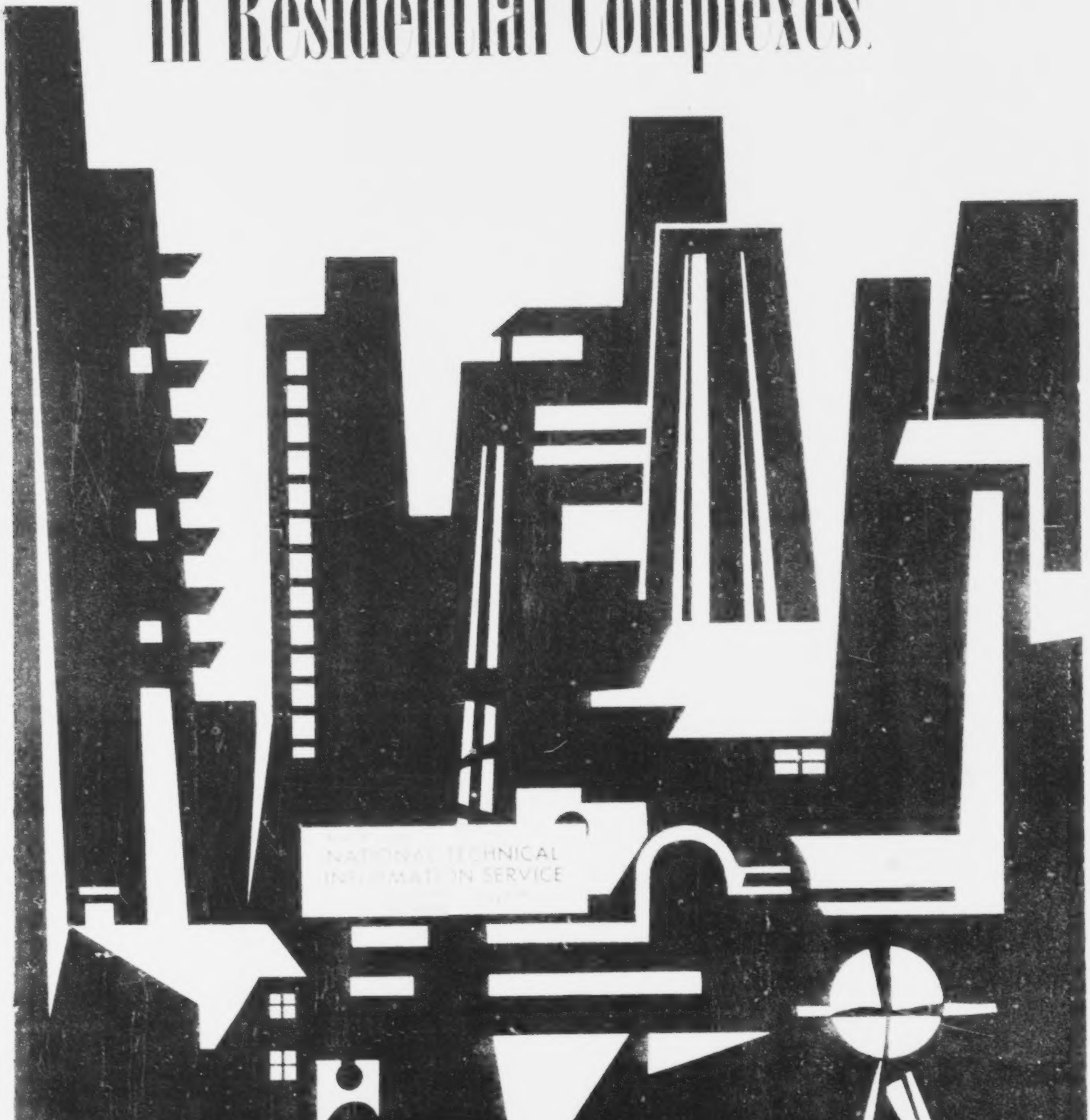

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SOLID WASTE MANAGEMENT IN RESIDENTIAL COMPLEXES

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FOREWORD

Major emphasis in improving waste management practices has been generally limited to the public and private systems of collection and disposal serving the entire community. Too few studies have been directed at the various types of building complexes and their respective waste system requirements. This study was designed for the investigation of the state of the art for such systems for housing complexes and the individual dwelling unit.

With increasing domestic waste production, new systems and devices are needed as solutions for handling, storage, and processing of waste materials at the point of generation in the dwelling unit and within the housing complex.

It is hoped that this study will aid the developer-designer team in: (1) identifying the internal solid waste problems in new building projects; (2) providing early guidelines for system requirements in the conceptual planning stages of such projects; (3) ultimately, selecting system components that will receive user acceptance and be compatible with local area solid waste management practices; (4) stimulating the continued engineering study of this vital problem.

--SAMUEL HALE, JR.
Deputy Assistant Administrator
for Solid Waste Management

PREFACE

This study was sponsored by the U.S. Department of Housing and Urban Development (USDHUD), and performed through interagency cooperation with the Office of Solid Waste Management Programs of the U.S. Environmental Protection Agency (EPA).

This report was prepared by the consulting firm of Greenleaf/Telesca, Planners, Engineers, and Architects, Miami, Florida, under Contract CPE 70-136 with EPA. It results from studies and investigations carried out by the firm for the primary purpose of determining alternative solid waste systems for those residential complexes in HUD's Operation Breakthrough Program, and recommending those conventional or innovative systems compatible with each site.

This report further identifies the basic solid waste system components and functions required in residential complexes and illustrates methods of evaluation of the different types of systems. It explores in some detail the types of hardware being marketed, or in the developing stage, from which these systems can be constructed.

These findings should be useful to designers, developers, and mortgagors of housing developments in both the public and private sectors. It is hoped this report will further stimulate continuing research in this field.

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SUMMARY TO THE REPORT ON SOLID WASTE MANAGEMENT IN RESIDENTIAL COMPLEXES

During the conceptual planning stages of the Operation Breakthrough project, Greenleaf/Telesca was selected to assist in the investigation and selection of solid waste systems for each of the projects. This assignment involved six principal tasks:

1. The accumulation of planning data on these projects.
2. Cataloguing data on equipment components and devices adaptable to solid management.
3. Determining requirements of solid waste systems for residential complexes.
4. Identification of systems' functions and structure and evaluation of the types of systems that could be considered.
5. Matching of candidate systems to sites with recommendations for a system installation at each site that would be compatible with planning objectives.
6. Recommendation of the scope of the continuing research program on systems selected for installation.

Planning Data

The accumulation of basic planning data was carried out by the initial review and reports prepared by the Site Planners and the continuing contact with the planners during the study period. Due to the general state of flux in the conceptual planning stage, data for purposes of this study was not firmed up on all projects until the latter part of October 1970. The summary of project descriptions (Table A) provides descriptive data then available on each of the projects.

Equipment Investigation

The investigation of equipment was carried out to identify the various types of devices and mechanical components that may be considered in structuring on-site solid waste systems.

The investigation of those equipment components either designed exclusively for or adaptable to solid waste system functions involved contact with about 150 manufacturers throughout the country.

Various types of processing equipment (such as compactors, balers, grinders, pulpers, incinerators) all offering a wide range of capacities have been developed for solid waste systems in buildings. Reduced storage space requirements can be accomplished by the use of such waste volume reduction devices and general building sanitation and safety can also be improved. Lesser progress is evident in on-site transport systems designed exclusively for solid waste. In addition to the practical and economical chute systems, available methods are

TABLE A

SUMMARY OF PROJECT DESCRIPTIONS

Proj. No.	Location	CHARACTERISTICS OF DWELLINGS Type (1) (2) (3)	Size Eff.	1BR	2BR	3BR	4BR	5BR	Total # of DU	Total Land Acres	Density DU A	Avg. DU Popul.	Est. Resident Popul.	ANCILLARY FACILITIES (Building Area - Square Feet) Comm. Center	Adm. & Maint.	Other Facil.	Total Area
1	Macon	LR SFD LD	-	-	-	8	12	-	20								
		LR SFA LD	-	-	45	99	26	-	170								
		LR MF MD	-	12	20	4	-	-	36								
		MR MF HD	-	-	18	6	-	-	24								
		HR MF HD	-	33	22	-	-	-	55								
		(TOTAL)	-	45	105	117	38	-	305	50	6	4.1	1,256	4,250	1,150	300	5,700
2	Memphis	LR SFA MD	-	-	18	58	6	-	82								
		LR MF MD	-	-	72	30	-	-	102								
		LR MF HD	100	100	92	-	-	-	292								
		(TOTAL)	100	100	182	88	6	-	476	12	40	3.2	1,528	NA	NA	NA	NA
3	St. Louis East Site	LR MF HD	17	7	65	41	-	-	130								
		MR MF HD	9	-	18	-	-	-	27								
		MR MF HD	20	40	20	4	-	-	84								
		(TOTAL)	46	47	103	45	-	-	241	7.6	31	3.0	720	NA	NA	NA	11,000
	West Site	LR SFA MD	-	-	10	25	40	-	75								
		LR MF MD	-	10	40	-	-	-	50								
		MR MF HD	-	-	25	-	-	-	25								
		HR MF HD	18	43	11	-	-	-	72								
		(TOTAL)	18	53	86	25	40	-	222	8	28	3.6	805	NA	NA	NA	8,700
4	Indianapolis	LR SFD LD	-	-	13	50	50	-	113								
		LR SFA MD	-	-	42	40	-	-	82								
	*LR&MR	* MF HD	-	50	55	-	-	-	105								
		(TOTAL)	-	50	110	90	50	-	300	52	6	4.1	1,230	3,000	NA	5,000	8,000
5	Kalamazoo	LR SFD LD	-	-	-	15	3	-	18								
		LR SFA MD	-	-	71	29	7	1	108								
		LR MF HD	3	50	33	8	-	-	94								
		(TOTAL)	3	50	104	52	10	1	220	35	6.3	3.4	756	2,000	NA	7,000	9,000
6	Jersey City	LR MF MD							NA								
		MR MF HD							NA								
		HR MF HD							NA								
		(TOTAL)	25	155	190	100	30	-	500	6.5	77	3.3	1,640	3,000	NA	65,000	68,000
7	Sacramento	LR SFD LD	-	-	-	9	11	-	20								
		LR SFA LD	-	-	24	97	60	-	181								
		LR MF MD	-	38	50	8	-	-	96								
		HR MF HD	-	110	-	-	-	-	110								
		(TOTAL)		148	74	114	71	-	407	32	12.7	3.9	1,585	13,000	1,000	4,000	18,000
8	Seattle	LR MF HD	-	-	-	23	11	3	37								
		MR MF HD	-	-	23	-	-	-	23								
		(TOTAL)	-	-	23	23	11	3	60	1.7	35	4.8	235	1,600	NA	4,500	6,100
9	King Co.	LR SFD LD	-	-	-	10	30	18	58								
		LR SFA LD	-	-	20	40	20	-	80								
		LR MF MD	-	-	12	12	-	-	24								
		(TOTAL)	-	-	32	62	50	18	162	30	5.4	5.5	900	3,000	NA	2,000	5,000

Explanation of Dwelling Types (1), (2), and (3)

(1) HR - High-rise (over 7 stories)
MR - Medium-rise (4 to 7 stories)
LR - Low-rise (under 4 stories)

(2) MF - Multifamily
SFA - Single Family Attached
SFD - Single Family Detached

(3) HD - High Density (over 20 DU/A)
MD - Medium Density (11 to 20 DU/A)
LD - Low Density (1 to 10 DU/A)

limited to prototype pneumatic conveyors and slurry pipelines. Where such methods can be adapted, interim storage points in building complexes can be further minimized.

Requirements of Systems

Requirements of solid waste systems for residential complexes are influenced by the mix of dwelling unit structures, site configuration, expected loadings, user habits, and the level of service required.

The total system must meet the varying requirements of the different types of dwelling unit structures (low-rise, medium-rise, and high-rise) and the ancillary structures. Reasonable standards and habits were adopted for handling the storage of wastes by the residents. Minimum standards were also adopted to establish the desired level of service compatible with Operation Breakthrough program objectives.

The criteria for the level of service was influenced by those planning objectives concerned with the environment and economics generally common to all Operation Breakthrough projects. Prime significance was given the environmental aspects of the level of service. It was determined that selection of a solid waste system and the management practices can be compatible with those planning objectives concerned with environmental characteristics. However, upgrading the level of service over conventional methods will likely increase cost of service and this condition is in conflict with the objectives to minimize development costs.

Identification and Evaluation of Systems

The four principal functions of a solid waste system can be identified as handling, storage, processing, and disposal. This study was concerned with the potential on-site systems and their relationship with these four functions and with their compatibility to the public collection and disposal practices in use at the Operation Breakthrough sites.

The system can be defined into four basic components or sub-systems:

1. The Unit System--Those initial functions in containing and moving waste from its point of creation to and including point of storage, processing, or disposal within the unit. The unit may be defined as a single dwelling unit or ancillary service area.
2. The Inter-Unit System--Those functions performed in the vertical and horizontal transport of waste from two or more unit storage areas to and including an intermediate storage, processing, or disposal point serving a group of units.
3. The Inter-Building System--Those functions performed in the transfer of waste from intermediate storage points to and including a central on-site storage processing or disposal facility.

4. The Off-Site System--Those functions performed in external transfer of waste from the central storage area to and including off-site processing or disposal.

In the investigation of solid waste systems suitable for residential complexes, nine basic functional variations were found (Table B). These variations are generally concerned with methods of transport, processing, and storage within each of the sub-systems. These functional variations in most cases suggest a broad classification of hardware that may be used and do not identify specific selection of equipment components. These systems also vary in the types of dwelling units to which they are adaptable and the types of waste materials to be handled.

Evaluation of identifying systems involves a comparison of system characteristics. The comparison is illustrated by a simplified deficiency rating of sub-systems characteristics of each system (Table C). These characteristics are generally concerned with various aspects of environmental quality, performance, adaptability, compatibility, and economy.

This comparison indicates advantages that may be expected by processing waste in the dwelling units and the subsequent transport of waste materials within a closed system. The advantages of such a

TABLE B

BASIC SOLID WASTE SYSTEMS FOR RESIDENTIAL COMPLEXES

System No.	Materials Handled			Dwelling Types Recommended					SUB-SYSTEMS									
									Dwelling Unit (DU)			Inter-Unit (IU)				Inter-Building (IB)		
	Garbage	Rubbish	Trash	LR/SFD	LR/SFA	LR/MF	MR/MF	HR/MF	Preparation	Processing	Storage	Transport		Processing	Storage	Transport	Processing	Storage
												Hor.	Vert.					
1	X			X	X	X	X	X	Segregate	Garbage Grinder	NR	Waste Line	Waste Line	NR	NR	Sewer Line	NR	NR
2	X	X	X	X	X	X			NR	NR	Lined Container	Manual or Vehicle	Manual	NR	NR or Bin	Vehicle	NR	NR or Bin
3	X	X	X		X	X			NR	NR	Lined Container	Manual	Manual	Console Compactor	Bag or Bale	Vehicle	NR	NR or Storage area
4	X	X					X	X	NR	NR	Lined Container	Manual	Gravity Chute	NR or Stationary Compactor	Bag, Bale or Container	Vehicle	NR	NR or Storage area
5	X	X				X	X	X	NR	NR	Lined Container	Manual	Gravity Chute	NR	Bin or Container	Vehicle	Stationary Compactor	Container
6	X	X					X	X	NR	NR	Lined Container	Manual	Gravity Chute	NR	Base of Chute	Pneumatic Tube	Stationary Compactor or Incin.	Container
7	X	X					X	X	NR	NR	Lined Container	Manual	Gravity Chute	Dry Grinding or Shredding	NR or Container	Pneumatic Tube	NR or Comp. or Incin.	Container
8	X	X					X	X	NR	NR	Lined Container	Manual	Gravity Chute	Wet Grinding or Pulping	NR	Slurry Pipeline	Dewatering	Container
9	X	X		X	X	X			NR	Under-Counter Compactor	Compactor Bag	Manual	Manual	NR	Bin or Container	Vehicle	NR	NR or Container

NR - Not Required

combination are illustrated by the low deficincy rating in the case of System 1 which utilizes grinders with sewer line transport of the processed materials.

Recommendations for Operation Breakthrough Projects

The established requirements of solid waste systems provide basic guidelines that must be considered for any residential complex in the planning stage. In addition, specific project conditions that would influence solid waste management must be considered for individual projects. These include the physical characteristics of the site (size, shape and proportion, topography and soils), site planning, local regulations, and the solid waste management practices. Other factors such as characteristics of the surrounding community, environmental quality requirements and area climatic conditions must also be considered in the selection of candidate systems.

With the analyses of site factors and the previous evaluation of systems (Table C), certain combination of systems appeared to satisfy the planning objectives of the Operation Breakthrough projects:

1. Garbage grinder installations appeared warranted for all projects.
2. The pneumatic collection system with a central compactor station seemed best suited to the needs of Jersey City and Memphis.

TABLE C

SUMMARY OF SYSTEM EVALUATION

SYSTEMS CHARACTERISTICS	SYSTEM NUMBER																																
	No. 1			No. 2a			No. 2b			No. 2c			No. 3			No. 4			No. 5			No. 6			No. 7			No. 8			No. 9		
	Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem		
	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB
1. Type of Waste																																	
a. Garbage	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	3	3	2	3	2	2	3	3	1	2	2	2
b. Rubbish	NA	NA	NA	2	2	2	2	2	2	2	2	2	2	1	1	2	1	2	2	3	2	2	1	1	2	1	1	2	1	1	0	1	1
c. Trash	NA	NA	NA	2	2	2	2	2	2	2	2	2	2	1	1	2	1	2	2	3	2	2	1	1	2	1	1	2	1	1	1	1	1
2. State of Development	1	0	0	2	1	1	2	1	1	2	1	1	2	2	0	2	1	1	2	2	1	2	1	2	2	4	2	2	4	1	2	1	1
3. Practicability and Operability	0	0	0	2	1	1	2	1	1	2	0	1	2	1	0	2	0	1	2	3	1	2	0	1	2	1	1	2	1	1	1	1	1
4. Economic Characteristics																																	
a. Economy of Increase Loading	0 -	0	0	0	2	2	0	3	2	0	0	2	0	2	2	0	0	2	0	3	3	0	0	0	0	1	0	0	1	0	1	2	2
b. Economy Throughout Expected Life	2	1	1	0	2	2	0	3	2	0	0	2	0	2	2	0	0	2	0	5	3	0	0	0	0	1	0	0	1	0	1	2	2
5. Reliability and Durability																																	
a. Demonstrated	2	1	1	1	2	2	1	2	2	1	1	2	1	2	2	1	2	2	1	3	2	1	2	2	1	3	2	1	3	1	1	2	2
b. Predicted	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	NA	2	0	NA	1	NA	0	NA	NA
6. Maintainability	1	0	0	2	2	2	2	2	2	2	1	2	2	1	1	2	2	2	2	4	2	2	2	2	2	3	2	2	3	1	1	2	2
7. Adaptability of Integration with,																																	
a. Other utility systems	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	0	NA	1	0	NA	NA	NA
b. Other maintenance services	NA	NA	NA	2	2	2	2	1	2	2	1	2	2	1	1	2	1	2	2	2	2	2	2	0	2	2	0	2	NA	0	1	1	2
8. Adaptability to Site Requirements	0	0	0	2	3	3	2	2	2	2	1	1	2	0	1	2	0	1	2	3	3	2	0	2	2	1	2	2	1	2	1	2	1
9. Adaptability for Disposal to,																																	
a. Sanitary landfill	NA	NA	NA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	1	1	1
b. Incineration	NA	NA	NA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	1	1	1
c. Recovery of resources	NA	NA	NA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	0	0	1	0	0	1	1	1
10. Environmental Quality																																	
a. Sanitation	1	0	0	2	2	2	2	2	2	2	2	1	2	1	1	2	1	1	2	4	3	2	1	0	2	2	0	2	2	1	0	1	1
b. Noise	1	0	0	2	3	3	2	2	3	2	2	2	2	1	1	2	1	2	2	3	3	2	1	2	2	3	2	2	3	2	0	1	1
c. Air pollution	2	0	0	2	2	2	2	2	2	2	2	1	2	1	1	2	2	1	2	4	3	2	2	1	2	3	1	2	3	0	0	1	1
e. Esthetics	2	0	0	3	3	3	3	3	3	3	3	2	3	1	2	3	1	2	3	4	3	3	1	0	3	2	0	3	1	0	0	2	1
11. Safety																																	
a. Fire and explosions	0	0	0	2	2	2	2	2	2	2	3	1	2	1	1	2	2	1	2	4	2	2	2	1	2	4	1	2	1	0	0	1	1
b. Public and operator	0	0	0	2	3	3	2	2	3	2	2	2	2	2	3	2	1	2	2	4	3	2	1	2	2	3	2	2	3	1	1	1	2
12. Operation Constraints	0	0	0	2	1	1	2	1	1	2	1	1	2	0	1	2	1	1	2	4	2	2	1	2	2	2	2	2	3	1	1	1	1
13. Adaptability to,																																	
a. Increased loading	0	0	0	2	2	2	2	1	2	2	1	2	2	1	1	2	0	2	2	4	2	2	0	0	2	1	0	2	1	0	1	1	2
b. Variation in waste characteristics	0	0	0	2	2	2	2	2	2	2	1	2	2	1	2	2	2	2	2	2	2	2	2	1	2	3	1	2	3	2	1	2	2
14. Availability for Meeting Construction Schedules	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0
15. Compatibility with Housing Types																																	
a. LR/SFD	0	0	0	0	0	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	NA	NA	NA	NA	0	0	0
b. LR/SFA	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	NA	NA	NA	NA	0	0	0
c. LR/MF	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	NA	NA	NA	NA	0	0	0
d. MR/MF	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	NA
e. HR/MF	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	NA
Deficiency Rating	12	2	2	40	47	47	40	42	44	40	33	37	40	28	30	40	25	37	40	71	52	40	25	20	40	48	33	40	43	17	19	31	33

NOTES: Deficiency Grading:

0	No deficiency
1	Very good or more adequate
2	Good or adequate
3	Fair or less adequate
4	Poor or needs improvement
5	Not suitable or inadequate

3. Individual chute-fed stationary compactor installations were compatible with the high-rise and medium-rise structures in the Macon, St. Louis, Indianapolis, Kalamazoo, Sacramento, and Seattle projects and suitable alternatives for such structures at Jersey City and Memphis.
4. Under-counter compactor units were recommended as the basic components in systems for low-rise structures in Macon, St. Louis, Indianapolis, Kalamazoo, Sacramento, and King County, and as suitable alternatives for such structures at Memphis and Seattle.
5. The console compactor was best suited for Seattle and a suitable alternative for clustered townhouses and low-rise apartments in all projects.

The project reports prepared during this study present the evaluation of various types of solid waste systems for each of the Operation Breakthrough sites, together with recommendations of system alternatives that would be compatible with site conditions and project objectives.

Economic summary of the recommended sytems (Table D) illustrates estimated capital costs and estimated total annual system costs for each project, with the latter reduced to annual costs per dwelling unit for comparison purposes.

TABLE D

ECONOMIC SUMMARY OF RECOMMENDED SOLID WASTE SYSTEMS

System No.	Dwelling Units		Capital Cost	Annual Operating Cost				Amortization of Capital Investment	Total Annual Cost	
	Type *	No.		Labor	Other Operating Costs	Municipal or Contract Costs	Total		Project	Per Du
Macon 1, 4, & 9	LR, MR, HR	305	$ 95,725	$4,375	$12,111	$5,490	$21,976	$13,105	$35,081	$115
Memphis 1, 4, & 9	LR, MR, HR	476	120,500	7,880	16,921	6,816	31,617	15,492	47,109	99
or 1 & 6	LR, MR, HR		579,500	2,555	13,292	5,712	21,559	42,612	64,171	135
St. Louis *1, 4, & 9	LR, MR, HR	241	67,425	3,605	8,667	4,338	16,612	9,477	26,089	108
**1, 4, & 9	LR, MR, HR	222	64,100	3,605	8,239	4,096	15,940	9,024	24,964	112
Indianapolis 1, 4, & 9	LR, MR	300	99,225	3,272	13,335	5,400	22,007	13,615	35,622	119
Kalamazoo 1 & 9	LR	220	74,050	2,500	9,080	3,960	14,860	10,180	25,040	114
Jersey City 6	LR, MR, HR	500	470,000	-	10,700	9,000	19,700	31,320	51,020	102
Sacramento 1, 4, & 9	LR, HR	407	120,535	4,935	15,291	7,326	27,452	16,536	43,988	108
Seattle 1 & 3 or	LR, MR	60	13,500	1,277	3,210	1,080	5,567	1,840	7,407	123
1, 4, & 9			19,300	946	2,636	1,080	4,668	2,641	7,309	122
King Co. 1 & 9	LR	162	54,430	1,300	6,671	2,916	10,887	7,481	18,368	113

* East Site
** West Site

The planning stages of all projects have progressed resulting in changes in the characteristics of projects, and it is likely that some features of the systems adopted herein are now obsolete. However, we feel that the guidelines for analysis contained in the report are sound.

Preliminary economic analysis of the various improved alternative systems show initial capital costs ranging from about $230 to $1,200 per dwelling unit, depending on the type of system and project density. Considering annual operating cost of each improved type of system and prorating capital cost over the life expectancy of system components, total annual costs per dwelling unit generally prevail in the range of $102 to $123 or about $8.50 to $10.50 per month. It is of interest to note that the pneumatic systems supplemented with kitchen grinders as considered for the Memphis project, where systems' capital costs (per dwelling unit) are the highest, total annual costs per dwelling unit are expected to be about $135 or $11.25 per month.

Proposed Continuation of this Study

The foregoing has described the principal activities undertaken under this contract. It was anticipated that certain of the recommended systems would be installed and that a continuing research program of the systems would be carried out. Tentative selection of the Memphis and Jersey City locations has since been made by HUD for installation of the pneumatic collection systems. In connection with this performance specifications (Appendix F) for the pneumatic collection systems were prepared as guidelines for procurement and evaluation of the system design.

As part of the current study (Phase I), the general scope of the continuing research program (Phase II) was prepared. The total scope of work to be undertaken in Phase II was subdivided into the design, construction, and operational stages with basic objectives in each stage identified in detail within this report.

ACKNOWLEDGEMENTS

This study was funded by the U.S. Department of Housing and Urban Development and, through interagency cooperation with the Office of Solid Waste Management Programs of the U.S. Environmental Protection Agency, was coordinated with activities and goals of EPA.

The consultants wish to acknowledge the assistance of EPA during the preparation of this study and the cooperation of staff members of HUD's Operation Breakthrough program, as well as the Site Planners and Developers of each Breakthrough project.

Sincere appreciation is also extended to the numerous equipment manufacturers who contributed time and effort in this study.

SOLID WASTE MANAGEMENT IN RESIDENTIAL COMPLEXES

This study was developed as a result of interdepartmental cooperation of the USDHUD and EPA. The Office of Solid Waste Management Programs was selected by HUD to direct an investigation and research of solid waste management practices for the nine housing developments in HUD's Operation Breakthrough Program, with the activities to be carried out during conceptual planning stages of these projects.

Need for the study was based on the concept that solid waste management practices in all types of building complexes are dictated by identifiable systems that require initial consideration in conceptual planning stages, not unlike considerations given to heating, air-conditioning, and plumbing systems.

Although the extent of mechanization of the solid waste system today is highly variable due to the relatively high costs and limited types of equipment adaptable to such systems, it is the goal of this study to emphasize the need for mechanization, wherever possible, as the sole permanent means of improving standards of operations of solid waste handling. This neither discounts the need for resident cooperation and skill of operating personnel required for satisfactory performance of such systems, nor does it omit the desired segregation of wastes as a function within the system for ultimate reclamation and recycling.

Purpose of Study

This study is primarily concerned with solid waste systems in individual types of residential buildings, ranging from the conventional single family detached dwelling to the high-rise multifamily dwelling, as well as combinations of dwelling types found in contemporary residential complexes, and including those ancillary facilities within the complexes.

The purposes of this study are multiple, including (1) evaluation of conventional and unconventional devices and methods that may be considered in the various types of dwelling units and complexes, (2) development and identification of systems (combinations of devices and methods) that are feasible in housing complexes, (3) establishment of procedures for the evaluation and selection of such systems as guidelines for system design by planners and developers, (4) application of these theories to the actual projects of HUD's Operation Breakthrough, and (5) selection of those Operation Breakthrough projects where improved systems are feasible, and prepare a proposed plan for conducting research on such projects that may be implemented.

Study Objectives

The ultimate objective of this project is to improve solid waste management in individual dwelling units and residential complexes. The initial objectives under Phase I, as reported herein, are to recommend solid waste systems for the Operation Breakthrough housing developments which will provide an improved level of service. Under Phase II, a proposed continuation of this study, broad objectives will include (1) the evaluation of design and construction of selected systems for various Operation Breakthrough sites, and (2) testing and evaluation of the performance of these systems over an extended operational period.

Characteristics of Solid Waste Systems

The descriptive nomenclature of solid waste systems in residential complexes, and the definitions of functions within the system, have been adopted in part from an earlier *study co-authored by the consultants.

Functions of the System: For purposes of this study, the four principal functions of a solid waste system are limited to waste handling, storage, processing, and disposal.

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*Solid Waste Handling and Disposal in Multistory Buildings and Hospitals, County of Los Angeles

The term "waste handling" includes all those functions associated with the transfer or movement of solid waste materials after creation, excluding storage and actual processing and/or ultimate disposal methods that may be employed. These waste handling fuctions are limited to and defined as follows:

collection - methods and equipment used in (1) the pickup of accumulated wastes from the initial point of deposit or subsequent storage points and (2) loading of vehicles or other means of conveyance for transport.

transport - methods and equipment used in the vertical or horizontal movement of materials.

discharge - methods and equipment used to unload wastes from the carrier or transporter.

Storage of wastes is the interim containment of accumulated materials in either loose, compacted, or other processed form prior to subsequent handling, processing, or disposal.

Waste processing is considered as those preparation functions, such as bagging or encapsulating of waste materials as well as treatments involving volume reduction through changes in size and shape, uniformity or consistency. The degree of volume reduction and corresponding increase in density varies with the method or combination of methods of these processes which precede ultimate disposal may include:

Bagging
Encapsulating
Compaction
Crushing
Shredding
Chipping
Grinding
Pulping
Pulverizing
Dewatering
Baling
Extrusion

Disposal is considered herein as the final treatment or combination of treatments in the conversion of wastes to innocuous materials or useable by-products. Generally, within the scope of this study, the significance of disposal is limited to the compatibility of residential solid waste systems to prevailing off-site disposal methods. However, destructive disposal processes, such as on-site incineration and grinding of domestic food wastes will later be considered as alternatives within the building system.

Nomenclature of the System: Identification of the system's basic components and working parts or functions of these components is a prerequisite to detailed investigation and analysis of actual working systems. For this identification, the requirements of the solid waste system (handling, storage, processing, and disposal), serving a residential complex and ancillary buildings, were resolved into four basic components or sub-systems:

1. The unit system--those initial functions performed in containing and moving waste from its point of creation to and including the point of storage, processing, or disposal within the unit. A unit may be defined as a single dwelling unit or ancillary service area.
2. The inter-unit system--those functions performed in the vertical or horizontal transfer of wastes from two or more unit storage areas to and including an intermediate storage, processing, or disposal point serving a group of units.
3. The inter-building system--those functions performed in the transfer of wastes from intermediate storage points to and including a central on-site storage, processing, or disposal point.
4. The off-site system--those functions performed in external transfer of wastes from the central storage area to and including off-site processing or disposal.

Definitions of Solid Waste Materials

The comprehensive terminology and definitions as employed by the American Public Works Association (APWA) in their publication "Municipal Refuse Disposal" describing wastes and the nature and character of refuse materials have been adopted for use in this study. APWA terminology and definitions pertinent to this study are as follows:

1. Waste refers to the useless, unwanted, or discarded materials resulting from normal community activities, including solids, liquids, and gases.
2. Solid wastes are classed as refuse.
3. The physical state of wastes may change in their conveyance or treatment. Dewatered sludge from waste water treatment plants may become solid wastes; garbage may be ground and discharged into sewers becoming waterborne wastes; and fly ash may be removed from stack discharges and disposed of as solid or as waterborne wastes.
4. Refuse comprises all of the solid wastes of the community, including semi-liquid or wet wastes with insufficient moisture or other liquid contents to be free-flowing.
5. The component materials of refuse can be classified by (a) point of origin, (b) the nature of the material itself, and (c) character of materials.
6. Special wastes are defined as (a) hazardous wastes by reason of their pathological, explosive, radioactive, or toxic nature, and (b) security wastes: confidential documents, negotiable papers, etc.

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6. Special wastes are defined as (a) hazardous wastes by reason of their pathological, explosive, radioactive, or toxic nature, and (b) security wastes: confidential documents, negotiable papers, etc.

Table 1 presents the APWA classification of refuse materials defining the character, nature, and kinds of typical materials as well as their conventional point of origin. Nearly all these kinds of refuse materials are produced in major building complexes. However, for purposes of this study, identification of solid waste materials generated in residential complexes will be generally limited to garbage, rubbish, bulky waste, and trash, with the latter defined as all waste materials exterior to buildings.

TABLE 1

CLASSIFICATION OF REFUSE MATERIALS

Kind or Character	Composition or Nature		Origin or Source
Garbage	Wastes from the preparation, cooking, and serving of food. Market refuse, waste from the handling, storage, and sale of produce and meats		From: households, institutions, and commercial concerns such as: hotels, stores, restaurants, markets, etc.
Rubbish or Mixed Refuse	Combustible (primarily organic)	Paper, cardboard, cartons Wood, boxes, excelsior Plastics Rags, cloth, bedding Leather, rubber Grass, leaves, yard trimmings	
	Noncombustible (primarily inorganic)	Metals, tin cans, metal foils Dirt Stones, bricks, ceramics, crockery Glass, bottles Other mineral refuse	
Ashes	Residue from fires used for cooking, heating buildings, incinerators, etc.		
Bulky Wastes	Large auto parts, tires Stoves, refrigerators, other large appliances Furniture, large crates Trees, branches, palm fronds, stumps, flotage		From: streets, sidewalks, alleys, vacant lots, etc.
Street refuse	Street sweepings, dirt Leaves Catch basin dirt Contents of litter receptacles		
Dead animals	Small animals: cats, dogs, poultry, etc. Large animals: horses, cows, etc.		
Abandoned vehicles	Automobiles, trucks		
Construction & Demolition wastes	Lumber, roofing, and sheathing scraps Rubble, broken concrete, plaster, etc. Conduit, pipe, wire, insulation, etc.		
Industrial refuse	Solid wastes resulting from industrial processes and manufacturing operations, such as: food-processing wastes, boiler house cinders, wood, plastic, and metal scraps and shavings, etc.		From: factories, power plants, etc.
Special wastes	Hazardous wastes: pathological wastes, explosives, radioactive materials Security wastes: confidential documents, negotiable papers, etc.		Households, hospitals, institutions, stores, industry, etc.
Animal and Agricultural wastes	Manures, crop residues		Farms, feed lots
Sewage treatment residues	Coarse screenings, grit, septic tank sludge, dewatered sludge		Sewage treatment plants, septic tanks

SOURCE: APWA - REFUSE COLLECTION PRACTICES

Description of Dwelling Unit and Building Types

Prevailing descriptive terminology of dwelling units and building types, as used by the Site Planners of the Operation Breakthrough projects, has been adopted for purposes of this study.

Classifications of buildings are limited to low-rise (LR) as under four stories, medium-rise (MR) between four to seven stories, and high-rise (HR) as seven stories or more.

Classifications of dwelling units are limited to multifamily (MF), single family attached (SFA), and single family detached (SFD).

Combinations of dwelling unit types with building height classifications are generally limited to the following:

LR-SFD - the conventional detached dwelling unit
LR-SFA - the conventional row-house or townhouse
LR-MF - the conventional garden apartment
MR-MF - conventional apartment buildings four to seven stories
HR-MF - conventional apartment buildings seven stories or more

Contemporary housing developments, including Operation Breakthrough's prototype communities, may contain any combination of building classifications, dwelling unit types and size mix, presenting complex requirements in on-site solid waste management.

REQUIREMENTS OF SOLID WASTE SYSTEMS

Certain factors affecting the selection of solid waste system components are common to all housing developments as well as the Operation Breakthrough projects. These factors are generally related to the system variations that are peculiar to the various types of dwelling units and the occupants' expected habits. Other factors such as types and quantities of wastes produced, the level of service desired, and economic considerations must be related to the individual project.

System Variations by Dwelling Unit Types

Mechanical accessories for handling, storing, or processing of solid wastes in the home are limited. With the exception of the kitchen garbage grinder, none of the available accessories are compatible with the system requirements of all types of dwelling units.

Occupants of single family attached (SFA) and detached (SFD) dwelling units are conditioned to the self-contained do-it-yourself aspects of waste storage and normally tolerate such facilities as the backdoor garbage can. Recent modifications in storage systems have seen the advent of various types of liners and bag systems, including special bag-holding devices which eliminate the need for the conventional container. Special mobile containers which are compatible with automatic loading devices on rear and side loading packer trucks have also been introduced. A kitchen compactor appliance now being marketed is one of the latest devices that appears compatible with the single family unit waste system. All of the above have the common purpose of providing interim storage for collection services of varying frequencies. However, each of the methods vary in characteristics or level of service. The occupants may also be provided with "backdoor" collection service, although gradually increasing costs of such service are dictating that curbside collection will likely prevail in most areas in the future.

Occupants of low-rise multifamily (LR/MF) dwelling units (such as garden apartments or the older two and three story apartment buildings with common stairs and interior or exterior corridor access to individual apartments) have a differing requirement in storage and handling of wastes. Although in some cases facilities provided for storage are comparable to those provided for single family dwelling, including rows of garbage cans in alleys or service areas, minor improvements such as common storage bins are gradually being adopted. In the case of buildings over two stories, chutes may also provide vertical transport to a central storage room and/or bin. More recent modifications to such systems include central compactors or balers at the base of chutes in buildings over two stories, or self-contained console compactors on the ground floor. If elevators are available for servicing the units and handling the large bales, locating console compactors on upper floors may also be practical.

The conventional systems found in medium-rise multifamily (MR/MF) and high-rise multifamily (HR/MF) apartment buildings, are generally limited to the trash chute for the vertical transport of solid wastes to a central storage room and/or bin and often coupled with on-site incineration. Advances in systems for these types of dwelling units have been largely limited to improvements in on-site incinerators and the development of compactors, both being adaptable for manual or chute feeding.

Contemporary housing developments may consist of any of the above building types exclusively or a mix of any combination of types. The Operation Breakthrough developments are likely representative of the combination of types of dwelling units, building types, and ancillary facilities that will be encountered in contemporary projects.

Selection of solid waste systems for such complexes may include consideration of a conventional system for each type of building and may prove feasible. However, building arrangements and access within the complex may limit the use of conventional storage and collection methods or in fact require management to implement an on-site system which replaces or supplements local municipal services. In case of large high density developments, mechanization of collection and storage functions by use of pneumatic conveyor systems or slurry pipelines may prove feasible. However, for conventional size projects, the usual solution within limits of proven methods will rely largely on manually operated vehicular transport. Economies in such methods will rely on compaction of wastes before transport to minimize bulk handling.

User Habits: Selection of systems for each housing development and the various types of dwelling units within the complex will, to a large extent, be governed by the judgement of user acceptance (the willing maximum effort and continuing cooperation of the tenant). For purposes of this study, the following basic assumptions are made:

1. Residents of LR/SFA, SFD, and MF can be expected to remove daily accumulations of wastes from within the dwelling unit to a conveniently located storage facility adjacent to the service entrance.
2. Residents of LR/SFA, SFD, and MF can be expected to hand-carry weekly accumulations of contained wastes a nominal distance of 100 feet to a point of deposit (interim storage).

3. Residents of LR/MF apartments (above first floor level) will remove daily accumulations but will not by choice remove the heavy and bulky accumulations of longer periods.
4. Residents of MR and HR/MF apartments can be expected to hand-carry daily accumulations of wastes a nominal horizontal distance of 100 feet to a point of deposit (such as the trash chute room).
5. Vertical transport of wastes in elevators by residents will not be permitted.
6. Distance limitation indicated above may be modified, providing the route of travel is a common route to other ancillary facilities such as parking areas, laundry, etc.

Level of Service Required: The criteria for the level of service indicated for Operation Breakthrough projects can be directly related to several basic design objectives which appear common to all those projects in the program. These objectives are as follows:

1. Preserve the natural assets of the site.
2. Create an optimum living environment.
3. Minimize vehicular and pedestrian conflicts.
4. Maintain recreational areas that are safe and secure with easy surveillance.
5. Provide methods of central service and facility design to reduce development and operating costs.

6. Minimize dwelling unit development costs.

Selection of the solid waste system and management practices can be compatible with those design objectives concerned with environmental characteristics and site configuration. However, it is unlikely that development and operating costs can be minimized while, at the same time, upgrading the level of service over conventional methods. Compromises, either in the level of service and/or economics, may be necessary in the final selection of the system.

The level of service and related solid waste management practices that are compatible with broad design objectives of the Operation Breakthrough projects must be identified preceding system design. The desired level of service for purposes of this study shall include the following minimum standards of operation:

1. Installation of garbage grinders is preferred in all dwelling units to process and evacuate the majority of putrescible wastes at the source.
2. Where garbage grinders are not installed, a minimum frequency of collection of wastes containing putrescible materials shall be established as twice weekly.
3. Where garbage grinders are installed, the collection frequency of mixed wastes shall be established as at least once weekly.

4. Accumulations of loose wastes shall be evacuated daily from dwelling units.
5. Accumulations of compacted wastes in a closed container shall be evacuated from dwelling units at least once weekly.
6. Individual outside storage facilities for waste materials, serving single family dwelling units, shall be limited to closed sanitary containers (lined cans or bag system) located above grade for safe handling by collectors and screened from public view.
7. A central storage facility, serving a group of dwelling units, shall be limited to adequately sized closed containers for loose bagged wastes, stationary packer containers, or a resident-operated console compactor station, screened from view, yet readily accessible to selected collection vehicles and service personnel.
8. Vertical transport of mixed wastes in medium- and high-rise structures shall be limited to a gravity chute.
9. Upon discharge of wastes from the vertical transport element in medium- and high-rise structures, materials shall be processed and/or containerized until collection or transport can be continued via an adaptable mechanized system.
10. Conventional collection vehicles will be permitted on principal access streets and drives where safe forward maneuverability of vehicles is possible.

11. Small satellite collection vehicles or multipurpose maintenance vehicles will be permitted in constricted service areas and pedestrian ways where safe forward maneuverability of vehicles is possible.

12. Vehicular collection of wastes shall be limited to daylight and offpeak traffic hours.

13. Central storage and/or processing areas serving the total housing complex shall be situated in a non-public enclosed area with adequate protection against fire, noise, air pollution, and unauthorized access, yet permitting easy and safe access to service vehicles and operating personnel.

14. All mechanical transport systems such as pneumatic conveyors shall have adequate protective devices at charging stations to permit maximum safety in operation.

The above suggested standards, related to various methods of waste transport, processing, and storage, are basically concerned with environmental quality control within systems operation. Such standards are broadly applicable to all projects, yet may likely be refined when a specific project is considered.

System Loadings (Quantities and Types of Wastes): The principal classifications of solid wastes generated in residential complexes are identified in this study as garbage, rubbish, bulky waste, and trash as defined by APWA classifications presented earlier. For the purpose of this study, an average daily per capita (resident) production factor of four pounds has been used in estimating daily quantities of wastes expected to be generated. This allowed production factor is based upon an expected average generation of 0.5 pounds of garbage, 3.0 pounds of rubbish, including bulky wastes, and 0.5 pounds of trash. For purposes of distribution within the residential complex, it is expected that the majority of garbage and rubbish will be generated in the dwelling units, with an allowance of only about 10 percent of the rubbish to be generated in ancillary areas. The allowance for trash is expected to consist of all materials generated in the outdoor areas, including parkways, parking, recreation, and pedestrian areas.

The above per capita production rate for wastes generated within the dwelling units is comparable to the national average of 3.0 pounds, as determined in the 1968 National Survey of Community Solid Waste Practices. This survey also cited an average annual increase of about 4 percent could be expected. Additional unpublished studies by the Office of Solid Waste Management further estimated the average density of normal residential wastes at 170 pounds per cubic yard or about 6 pounds per cubic foot.

Utilizing the density factor of 6 pounds per cubic foot, source distribution of daily per capita production of total wastes is further summarized as follows:

Source	Garbage	Rubbish	Trash	Total	
	lbs	lbs	lbs	lbs	cu ft
Dwelling Unit	0.5	2.7	-	3.2	0.53
Ancillary Areas	-	0.3	-	0.3	.05
Outdoor Areas	-	-	0.5	0.5	0.08
Total (lbs)	0.5	3.0	0.5	4.0	-
Total (cu ft)	0.08	0.5	0.08	-	0.66

Total estimated quantities of wastes later determined for each of the Operation Breakthrough sites are based upon the above average per capita production factors, together with population estimates of the respective projects. The adoption of average per capita production factors are considered reasonable and adequate for estimating daily waste quantities generated in residential complexes such as proposed in the Operation Breakthrough program, including basic resident related services and recreational facilities. However, additional allowances should be provided for non-resident related facilities such as commercial space, office space, and schools that may be incorporated in these complexes. Present data available on ancillary facilities within the Operation Breakthrough are inconclusive at the time of preparation of this report, and the above noted allowances have been adopted, in most cases, without further adjustment.

METHODS AND EQUIPMENT FOR USE IN SOLID WASTE SYSTEMS

This study involves the investigation of the various methods and equipment which can be used in residential complexes to form a system for accomplishing the on-site transfer of solid wastes from points of origin or generation to areas for storage or processing prior to off-site disposal. It is also concerned with the effect of such systems on off-site transfer and disposal methods.

The problems considered are those encountered in ridding the individual household of its daily accumulation of wastes. Within the household itself the materials to be disposed of will include food wastes, paper, glass, metal, and plastic products, and miscellaneous unwanted or broken articles which are of no further use. Outdoor wastes such as grass, shrubbery cuttings, and general yard litter are also considered.

The primary function of any solid waste system is to reduce manual operation to a minimum by the proper use of devices and mechanisms without compromising sanitation. The components of such systems may be as simple as a special paper bag suspended in a holder; a plastic bag or liner for a barrel or other container; or they may be quite complex and semi-automated installations such as a stationary compactor with a pneumatic conveyor to load it. Regardless of simplicity or complexity, any system should accomplish its purpose safely and efficiently, reduce human handling as much as reasonably possible, and be economically feasible.

The installation of a solid waste system in any residential complex will not automatically solve the problems of handling and disposal. No system will function satisfactorily unless it is properly used. All tenants or other users must perform some manual operations and they should be adequately instructed. Some hand separation of wastes may be required, especially if salvage and recycling is to be practiced.

The evaluation of various types of equipment and system components has taken into consideration many factors. They include, but are not limited to, the following items:

Capabilities - What will the device or mechanism do? Will its use be an improvement over common or usual practices?

Reliability - Will the equipment carry out its designed functions with little attention beyond periodic preventive maintenance? Has its effectiveness been demonstrated in use over a reasonable period of time or merely predicted?

Service - Servicing beyond the capabilities of the local building maintenance staff may be occasionally required. Are properly trained service men readily available through the equipment manufacturer or his local distributor?

Safety of Operation - Some operation of equipment and systems will be carried out by tenants or, at best, by building personnel with limited mechanical knowledge or abilities. Is the proposed equipment reasonably foolproof? Does it have safeguards which discourage careless use?

Ease of Operation - Unless functions and actual operations of systems are easily carried out or operated, they may be ignored or "short circuited" by paid personnel and certainly by "paying" tenants. If tenants or others are deterred in the use of systems, because of the complicated mechanical nature or difficult use of system components, then existing problems have not been solved and new ones may have been created, including the continuing cost of the system without benefit of use.

Efficiency - The component selected must perform efficiently and with a minimum of attention. It must be relatively trouble-free and require only very occasional servicing. It should carry out its complete cycle of functions each and every time it is used or actuated.

Pollution of the Environment - No component selected should pollute or contaminate the environment. Components should, if possible, reduce environmental pollution below the levels presently associated with like functions. Some increase in operational cost is justifiable if pollution or contamination levels can be made lower.

Economy - Several economic factors have already been touched upon but of course, the principal ones are capital investment and operational costs. The precedence which these two factors may take, one over the other, cannot be categorically stated for all conditions. Each must be weighed against the other for every type of equipment under consideration. First cost is of the utmost importance but, in many instances, it may be offset by the probability of the long and trouble-free life of specific mechanisms. Components produced by well established companies, having a proven history of satisfactory operation, should be given appropriate consideration, all other factors being equal.

Health Hazards - No hazard to health should be created or amplified by any device or mechanism.

Esthetics - Equipment and its arrangement should not be offensive to the senses. The processes of the handling and disposal of solid wastes do not lend themselves to beautification, of themselves, but every effort must be made to reduce or eliminate offending sights, odors, and noises.

Total Feasibility - Any final selection must be governed by analysis of the several factors which contribute to project feasibility. Some factors cannot be reduced to numerical values which can be subjected to common arithmetical manipulation. In the final analysis, human judgment must be the deciding factor.

The foregoing factors are not necessarily arranged in proper sequence of their relative importance, nor has every possible consideration been included. The various items will carry differing weights and values, depending upon the type of device or equipment being considered.

The materials included in this section of the report have been organized by the following functional classifications:

Handling Methods and Equipment

Storage Methods and Equipment

Processing Methods and Equipment

Descriptions of various types of equipment are provided in brief form. Some of the equipment included in the discussion is still in the conceptual or experimental stage. Still other components or systems are available but not yet well tried in practical operation. All of the equipment discussed may not be particularly applicable to the housing projects under study. They have been included to provide a better rounded report on possible methods of handling, storage, processing, and disposal of solid wastes. Some of them, while somewhat exotic today, may be commonly accepted practices tomorrow.

Also included are tabulations of currently available models or types of devices and equipment. These tabulations include, where applicable and available from manufacturers' data, space requirements and approximate prices. In general, prices shown are those given by manufacturers and/or distributors as list. Freight and/or installation costs are not included in the tabulations. The various manufacturers are identified only by code numbers in the tabulations. The code numbers applicable to the specific manufacturers are provided in Appendix A. Listing of manufacturers by equipment types is provided in Appendix B. An alphabetical list of manufacturers, including many whose products are not included in the tabulations, is also provided in Appendix C.

Handling Methods and Equipment

Included in this section, as well as in those following, are brief descriptions of various means of handling solid wastes and some of the equipment which is available to accomplish the objectives through the reduction of manual operation. It is recognized that some of the data included is not applicable to all, or possibly, any of the housing complexes which comprise the present project, but may have value for future reference or further study.

The information is arranged alphabetically, by types of equipment, and is not ranked in any order of value or precedence.

Cart, Collection, Refuse: Wheeled and castered refuse collection carts can provide both storage and transport facilities in a single piece of equipment. Many styles are available, such as tilting, pickup, lift, hamper, etc. Those made of resilient, heavy plastic materials are durable, safe to handle, and can be readily cleaned.

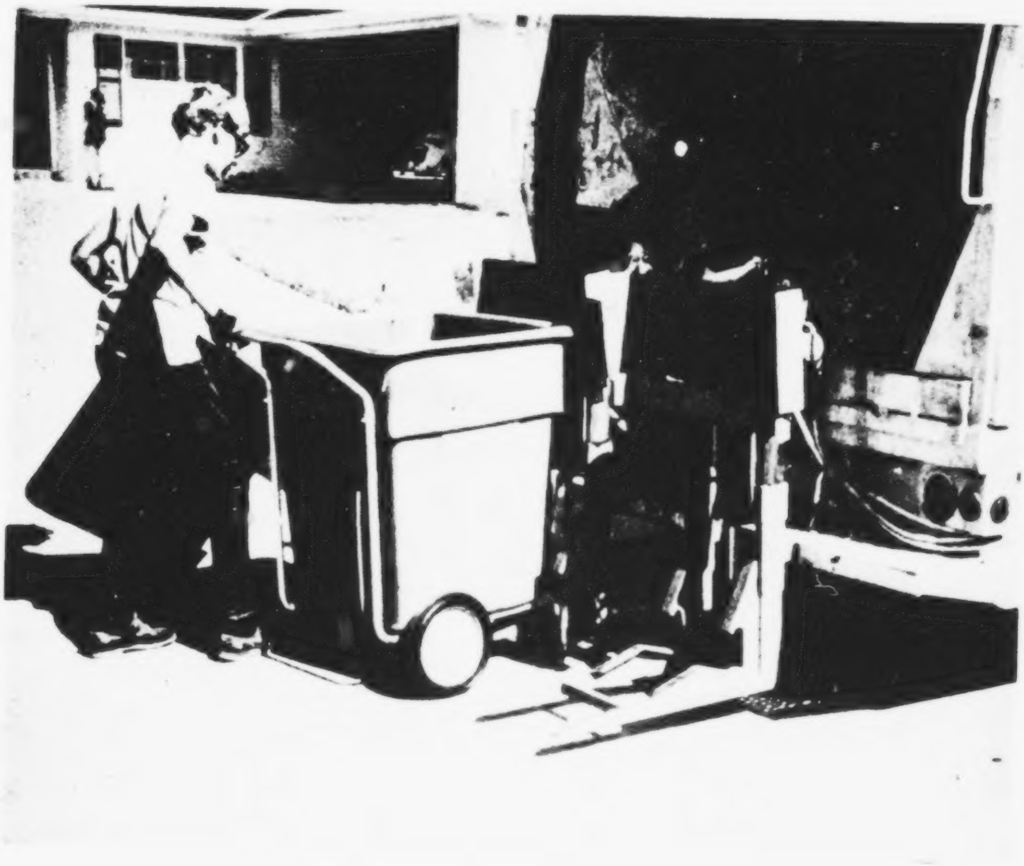
The approximate capacities of the wheeled carts vary from 12 cubic feet to one cubic yard. Castered carts, generally of the hamper-type, vary in capacities from eight to 36 cubic feet. They are less convenient to use than the tilting type but also are less costly.

Castered carts of the hamper and barrel types are made by Rubbermaid Commercial Products, Inc. and Fusion Rubbermaid.

An innovation in the use of large, wheeled carts is a lifting mechanism which can be attached to the receiving hoppers of mobile packers. Two such systems are on the market and, although without long experience records, appear to be practical additions to refuse collection methods. These hydraulically operated lifts cost about $500 each and are of such size as to permit a pair to be attached to the rear of most mobile packers. One of these systems can also be used with side-loading packers. Their attachment does not appear to interfere with the

CART, COLLECTION, REFUSE

Make	Model	Type	Wheeled or Castered	Approximate Capacity	Maximum Load Lbs	Overall Dimension Inches	Weight Lbs	Lids Available	Lift System Available	Price	REMARKS
14000	---	Pick up	Wheeled	8 cu ft	NA	31x20x37H	28	NA	No	$ 50	
14001	1010	Tilt	Wheeled	.5 cu yd	700	55x29x36H	138	Yes	No	135	
	1014	Tilt	Wheeled	1 cu yd	800	65x36x42H	159	Yes	No	160	(see also #10004)
	1015	Tilt	Wheeled	1 cu yd	1000	65x36x42H	170	Yes	No	175	
	4010	Lift	Wheeled	80 gals	200	37x27x46H	54	Yes	$500	45	Lifts can be attached to mobile packers
	2008	Hamper	Castered	8 cu ft	NA	34x22x28H	35	Yes	No	55	
	2012	Hamper	Castered	12 cu ft	NA	36x25x34H	60	Yes	No	75	
	2014	Hamper	Castered	17 cu ft	NA	39x28x36H	71	Yes	No	87	
	2020	Hamper	Castered	24 cu ft	NA	48x31x30H	83	Yes	No	111	
	2029	Hamper	Castered	36 cu ft	NA	51x39x43H	125	Yes	No	155	
14002	---	Lift	Wheeled	82 gals	200	37x28x41H	45	Yes	$500	40	Lifts can be attached to mobile packers



INDIVIDUAL CONTAINER LIFT MECHANISMS

conventional methods of loading mobile packers.

The special carts used with these lift systems consist of a two-wheeled, sturdy, tubular metal frame to which is attached a plastic container of 80 gallons, or about eleven cubic feet capacity. The cart frame has convenient handles and the container is fitted with a plastic lid.

In use, the container-cart can be kept indoors or outside and can be easily wheeled about for the collection of yard rubbish and cuttings. When filled it can be readily moved to a collection point or to a mobile packer. The appearance of the cart is not objectionable in residential areas and its use avoids bodily contact with a dirty container by both the householder and the collector.

The materials and construction of these carts are durable. The handling of the heavy plastic container does not create objectionable noise.

Chute, Gravity: Although this classification of transport equipment includes such types as spiral chutes, this discussion is limited to the vertical tube type. Tubes are commonly fabricated of aluminum, aluminized steel, or stainless steel, and range upward in cost in the order named. Aluminum is not recommended for high-rise rubbish chutes, but if used, should not be thinner than #16 Brown & Sharpe gauge.

Aluminum being softer is less durable than steel. The walls of an aluminum chute are subject to abrasion and possible puncture from heavy and sharp objects which might be put into a chute. Tubes made of #18 or #16 U.S. gauge aluminized steel are most commonly used in apartment installations for the handling of rubbish or trash. In high-rise structures the heavier gauge is used for the lower floors and the lighter gauge sheet may be used for the upper stories. Stainless steel Types 409 and 430, of #18 or #16 gauge is also used. Unlike aluminized steel, it has no coating to wear; has higher impact strength and a longer life, but is more expensive.

The chutes are commonly made in cylindrical form, as opposed to a square configuration, to provide greater strength with the use of less material for a given diameter than the same dimensioned square shape. The cylinder, having no corners, is more readily cleaned and provides less probability of the accumulation of dirt and putrescible matter which might attract insects. It is possible to prefabricate cylindrical sections of tubes which might be made of cement-asbestos material or lightweight precast concrete but the weight of long sections of tubes of these materials would be much greater than the same length of metal tube.

Chutes are available in diameters from 12" to 36", with 24" being average and usual. All sizes can be furnished with suitable intake

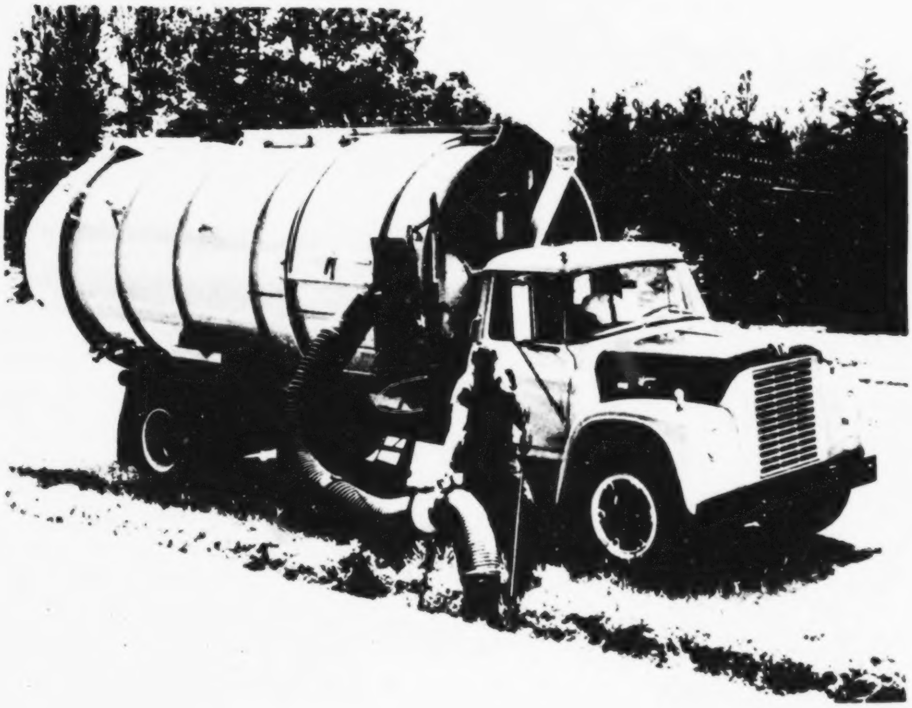
CHUTE, GRAVITY

Make	Diameter	Intake Door	Chute Material	U.S. Gage	PRICE			REMARKS
					Per Story	Erection	Total	
2000	24"	15"x18"	Aluminized Steel	#16	$186.00	$48.00	$234.00	Optional equipment: sprinklers; disinfecting system; sound insulation; horizontal belt conveyor
	24"	15"x18"	Aluminum	#16	$140.00	$50.00	$190.00	
	24"	15"x18"	Stainless Steel	#16	$264.00	$50.00	$314.00	
2001	24"	15"x18"	Aluminized Steel	#16	$158.00 to $167.00	$50.00	$208.00 to $237.00	Optional equipment: sprinklers; disinfecting system; sound insulation; smoke detectors
	24"	15"x18"	Aluminum	#16	$165.00	$50.00	$215.00	
	24"	15"x18"	Stainless Steel	#16	$220.00 to $240.00	$60.00	$280.00 to $300.00	

doors, either side or bottom hinged, for installation on various floor levels. Accessories such as back draft baffles at intake stations; door locks; sprinklers; disinfecting systems; sound insulation; roof vents, etc. can be furnished. A disinfecting and sanitizing unit can (and should be) added at the top of each vertical riser in the trash chute system. These units are pressure-operated sprays which add disinfectants to the spray water. The general cleanliness and odor-free condition of the chute is largely dependent upon the frequency of the use of the sanitizing unit.

Prices of basic standard chutes, excluding required building enclosures (chase walls), will vary from \$140 to \$270 per story, depending upon the materials of which they are made. Erection cost will be about \$50 to \$60 per story. If an aluminized steel chute, 24" in diameter, is used as a base or standard and its cost, not including erection, is considered to be 100 percent, then a chute made of aluminum in similar gauge will cost about 25 percent less. A comparable stainless chute will cost about 42 percent more. Aluminized steel is considered by chute manufacturers to be standard and to have a life equal to that of the average building in which it is installed.

Conveyor, Litter, Vacuum: This unique vacuum device, originally designed for collecting leaves and cleaning small dry debris from shallow



LITTER VACUUM CONVEYOR

ditches, also has other applications and capabilities such as cleaning general litter from around trash dumping or processing areas.

This accessory, manufactured by Truck Equipment Corporation and called a Tecorp Leaf Collector, can be added to Truxmore side-loader mobile packers at an added cost of about $3,500. It consists of a gasoline motor driven vacuum unit which can be mounted between the packer body and the truck cab. A large diameter, flexible hose and nozzle are connected to the unit when in use and can easily be handled by one man. The manufacturer claims collected debris passes through a self-cleaning impeller which chops the material and blows it into the packer body. The suction hose is easily detachable for storing.

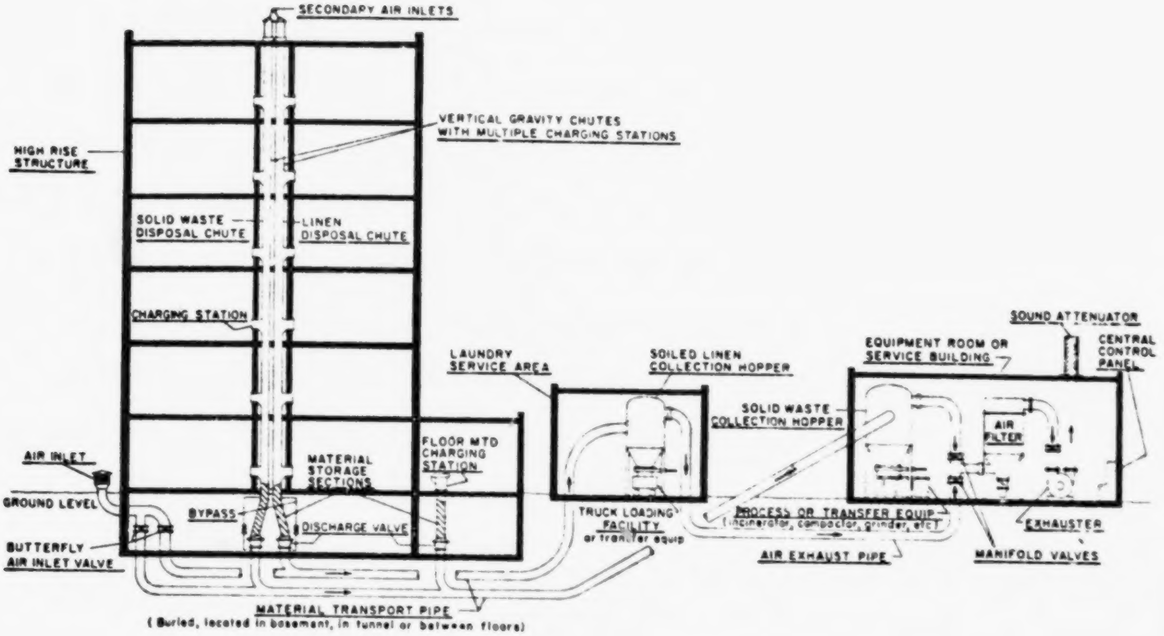
Conveyor, Pneumatic: This method of conveying consists of a system of tubes in which air, either under positive or negative pressure, is used to move specially designed carriers, loose or bagged objects, or bulk materials. In its simplest, and probably best known form, it is used to transport documents or small objects, in special containers, within commercial or institutional buildings.

Pneumatic conveying of loose or bulk materials is a common method used by industry today. The same principles are being applied successfully to the transport of solid wastes in building complexes.

There are presently three known systems of different origin in limited use today and each will be briefly discussed.

Envirogenics Company: One transport system was developed in Sweden under the trade name "AB Centralsug". It is now produced and marketed in the United States by Envirogenics Company, a division of Aerojet-General Corp. under the trade name "AVAC"--Automated Vacuum Collection systems. A pilot system was built by Aerojet-General at its El Monte, California, plant. Originally conceived and designed to handle soiled linen and solid wastes in hospitals, its use for those purposes is fairly extensive in Sweden and to a lesser degree elsewhere in Europe. This system has also been adapted to the transport of solid wastes in large residential complexes in Sweden.

The AVAC system is described by the manufacturer as a horizontal system of pipes with an exhauster at one end and air inlets at the end of each branch line. When the system is in operation, a vacuum is developed at the inlet of the exhauster and a high velocity air stream is drawn through the transport pipes from the air inlets, one at a time. Throughout the system, vertical gravity chutes are provided with valved transitions to the horizontal pipe system. Waste material is collected and stored at the base of the vertical chutes and then dropped into the moving air stream, one chute at a time. The air stream carries the


SECONDARY AIR INLETS
VERTICAL GRAVITY CHUTES WITH MULTIPLE CHARGING STATIONS
HIGH RISE STRUCTURE
SOLID WASTE DISPOSAL CHUTE
LINEN DISPOSAL CHUTE
CHARGING STATION
AIR INLET
GROUND LEVEL
BUTTERFLY AIR INLET VALVE
BYPASS
MATERIAL STORAGE SECTIONS
DISCHARGE VALVE
FLOOR MTD CHARGING STATION
MATERIAL TRANSPORT PIPE
(Buried, located in basement, in tunnel or between floors)
LAUNDRY SERVICE AREA
SOILED LINEN COLLECTION HOPPER
TRUCK LOADING FACILITY or transfer equip
SOLID WASTE COLLECTION HOPPER
PROCESS OR TRANSFER EQUIP (incinerator, compactor, grinder, etc)
AIR EXHAUST PIPE
EQUIPMENT ROOM OR SERVICE BUILDING
SOUND ATTENUATOR
CENTRAL CONTROL PANEL
AIR FILTER
EXHAUSTER
MANIFOLD VALVES

Schematic Diagram of an AVAC System

Shown above is a simplified diagrammatic sketch of a typical dual system for transporting solid waste and soiled linen. Directly above in the sketch is the air inlet, a screened opening. In a system with branches, butterfly valves are provided downstream of the air inlet to ensure that only one branch operates at any given time.

Proceeding to the right of the air inlet, the sketch portrays two vertical gravity chutes - one for solid waste and the other for soiled linen - with charging stations on each floor of the structure. At the bottom of the chutes, material storage sections and pneumatic cylinder-operated slide-type discharge valves are incorporated.

In multistory buildings, bypasses normally will be provided around the valves to allow a constant air flow and to maintain a slight negative pressure in the vertical chutes. This is maintained by a small exhaust blower. As indicated, secondary inlets are provided at the top of the chutes on the exterior of the structure. This arrangement continually removes air carrying dust, odors, or contaminants from the vertical gravity chutes. When the system includes a series of vertical chutes in one branch, the discharge valves will operate in sequence; the first valve to open will be the one closest to the exhauster. To the right of the gravity chutes (the next branch downstream) is a typical floor-mounted charging station. Such units can be provided in the garden for cuttings, in the kitchen for cans, boxes, bags, wrappings and other waste; or in any area in which there might be a rapid accumulation of waste.

A high velocity air stream carries the materials from the material storage sections and discharge valves through the material transport pipes to their respective collection hoppers in the laundry service area, and in the equipment room or service building. The air continues through the collection hoppers leaving the material load in the hopper. A grating or screen is provided in the hopper to protect the exhauster by preventing coarse materials from being carried further downstream. Provisions are generally made for automatic removal of trash from the solid waste collection hopper to such processing equipment as shredders, balers, compactors, incinerators or other equipment used for trash disposal. From the soiled linen collection hopper, automatic removal is generally provided to a truck loading facility, or to transfer equipment for removal to appropriate stations in the laundry.

The air then flows through air exhaust pipes and manifold valves to an air-cleaning device (identified in the sketch as an air filter). The extent of filtration is determined by specific customer requirements. A wide range of filters is available, from throw-away types of nominal capability to bag filters, electrostatic filters, or absolute filters.

Finally, the air discharges through the exhauster, which is a heavy duty blower. The capacity of the exhauster is determined by the length of the runs, the materials to be carried, piping configuration, and other design parameters.

The sketch indicates a sound attenuator at the exhaust end of the line on the exterior of the equipment room or service building. Requirements for noise reduction devices will vary dependent upon the distance of the exhaust from occupied buildings and the nature of the occupancy. Noise reduction can be accomplished by enlarged exhaust outlet ducts, insulation, baffled chambers, or mufflers.

PNEUMATIC CONVEYOR

material to a collection hopper, leaves the material in the hopper, continues on to the exhauster, and then discharges to the atmosphere. Air moves in the system at the rate of 80 feet per second or about 60 miles per hour.

The system is not continuous in its operation. After each cycle, the collection hoppers are emptied automatically into equipment for ultimate disposal and processing. The system must be actuated either by pushbutton or it may be placed under a time cycle control or on a demand basis through limit switch controls at storage points.

Construction materials and sizing of the tube system can, of course, vary if special requirements of a particular project so dictate. However, a typical system utilizes the following materials:

20-inch diameter pipe of carbon steel, coated and wrapped when used underground;

A pipe wall thickness of 1/4-inch for all buried lines and for trash lines aboveground;

A pipe wall thickness of 1/8-inch for air exhaust lines aboveground and material storage sections;

Wall thickness of trash lines is increased to 3/8-inch for bends;

Aluminized steel vertical chutes of 16 gauge is generally used although 14 gauge metal may sometimes be required.

The pipe presently being used in the United States may be either spirally wound or of the longitudinal seam type. The weight of pipe with 1/4-inch wall thickness is about 53 pounds per foot. Insulation and sound deadening is accomplished by the use of 1/64-inch "Acoustilead" and 2-inch thick "Fiberglas". Cathodic protection is recommended for pipe subject to corrosive soil conditions.

The AVAC system has capability to move material in any direction, under air power, after material is discharged from chute storage into the airstream. Initial vertical movement is limited to a downward direction utilizing conventional gravity chutes. The manufacturer has demonstrated in the pilot plant that material can be lifted about 30 feet vertically. Although vertically upward travel is entirely feasible the manufacturer does not recommend it for transport of unclassified trash that often contains broken glass, discarded tools, rocks and other objects of high density that will not travel vertically when segregated. The use of heavy-duty trash bags would remedy this but becomes prohibitive, cost-wise when bags are used in large quantities. Therefore, the manufacturer usually limits the upward angle for trash transport piping to 30 degrees. With this angle, dropped out objects are shoved forward with each passing trash load and eventually reach the collection silo, as demonstrated in existing Swedish systems as well as in the manufacturers test unit.

Eastern Cyclone Industries, Inc.: The "Air-Flyte" system was originally designed and developed by E.C.I. to handle linen in laundries, especially those providing diaper services. It has since been adapted for installation in hospitals and has been recently designed for the transport of wastes in residential complexes. An installation, handling solid wastes, is in use at Alta Bates Hospital, Berkeley, California. A prototype demonstration system is operating at the E.C.I. plant at Fairfield, New Jersey.

The "Air-Flyte" system uses negative air pressure to move bagged wastes to points of processing or disposal through a tube or piping system from depository stations strategically located within buildings or a building complex. The most common system employs a single tube, usually between 12 and 20 inches in diameter. For hospital installations, automatic switching devices make it possible to divert linens or trash to the proper destination. Single tube systems can be equipped with either one or two door depository stations, although both in the latter case are connected to the same single tube. Systems can be installed in which separate tubes are provided for linen and trash. The operations of single or two door systems and single or dual tube systems are controlled by pushbutton at the loading station.

Each loading station consists of a built-in housing with an outer access door flush with the wall. An inner door, which is air operated, provides the closure between the station and the main air tube of the system. The outer door can be opened only when the inner door is closed and thus no air from the system is expelled into the building nor can inside air be drawn into the system.

When bagged or loose trash is introduced into the system, the outer door is opened, the bag placed inside the receiving station, the outer door is closed, and the actuating button (which can be key locked) pushed. By means of an electronic memory system and a series of actuating relays, the inner door is automatically opened and the bag is drawn into the air tube for transport to its destination.

The basic system is engineered to dispatch but one bag from one loading station to a selected destination at any given time. The memory system, like the type used for elevator control, will record demands from a number of stations and actuate the inner doors of the various receivers throughout the system in a time sequence corresponding to the order in which the demands were placed. When one delivery is completed, the next in the demand sequence will be commenced and subsequently completed before a new cycle will begin.

Modifications are now in the development stage to adapt this pneumatic conveyor system to conventional gravity chutes with a valved transition admitting accumulated wastes to the pneumatic pipeline.

Necessary fire control devices can be incorporated in the pneumatic systems. Fire dampers, which are accordion-pleated devices that drop vertically across the airstream, are controlled by fusible links and can be installed in accordance with prevailing codes. Likewise, sprinkler systems can be installed to comply with local regulations.

Trans-Vac Systems: This division of Montgomery Industries, Inc. is corporately related to the Jacksonville Blow Pipe Company, the latter being long time designers and manufacturers of shredders, hoggers and other material destructing equipment, as well as pneumatic transport systems designed primarily for heavy industrial uses.

Trans-Vac is offered for applications which would utilize a vacuum system, a combination gravity-pneumatic system, or a positive pressure system. The vacuum application consists of a closed tube system in which negative pressure is maintained during operation. It is recommended for installations where there will be offsets in vertical risers and/or when double door loading stations are desired, such as in hospitals and institutions where both soiled linens and trash would be handled by the main airstream. Gravity-pneumatic applications employ a system of vertical risers, without any offsets, such as standard gravity chutes which allow materials to fall by gravity to a horizontal pickup point for lateral transfer to a collection point. A make-up air source is required at the lateral transfer point. Positive pressure applications require a closed tube system with roof mounted blower. This eliminates a long lead pipe run where collectors are located at a low level within the building structure.

Because of its long experience in shredding and granulating a wide variety of materials and the transport of materials before and after size reduction, Montgomery Industries, Inc. and Jacksonville Blow Pipe Company have custom designed waste disposal systems which are capable of shredding glass, plastics, metal, and other types of waste materials prior to their delivery to various types of containers, stationary compactors, or to incinerators.

Typical specifications for a waste disposal transport system include the use of standard, tubular gravity chutes, 16 inches in diameter and of 18 gauge galvanized steel constructed in 8-foot long sections. Elbows are commonly made of 16 gauge galvanized steel.

Underground piping would be designed to meet the conditions of the particular installation. Insulating and sound-deadening materials are employed where required.

As in other pneumatic systems necessary fire control devices can be incorporated. These include fire dampers, controlled by fusible links. Sprinkler systems can also be installed to comply with local regulations.

Manufacturers of Trans-Vac think of it as an especially engineered system, specifically designed for a particular application--as opposed to the accumulation of standard components. An operating prototype system has been built at the Jacksonville, Florida, plant of Montgomery Industries, Inc. and for which the manufacturer claims full capability for the movement of bagged or loose wastes within or between buildings to a central collection station for processing and/or storage.

Hoist, Container, Rear Loading: These heavy duty truck mounted hoist systems are designed to handle large special purpose containers, including tanks and bins. This type of unit is not to be confused with a mobile packer hoist. Container hoists are capable of lifting, transporting, and dumping or depositing containers having capacities as large as 15 or 16 cubic yards. This type of equipment is largely used in industry for handling many types of materials, including loose and compacted wastes and can be handled by one man on a truck.

The "Dempster Dumpster" by Dempster Brothers and the "Load Lugger" by The Heil Company have somewhat similar features although the actual hoisting systems differ slightly. These lifting systems are hydraulically operated and utilize a lift, swing and set operation which is accomplished by a pair of heavy arms pivoted at the bottom of the hoist, at chassis level. Both types of hoist are mounted on medium size truck chassis of relatively short wheel base. They are capable of lifting, transporting, depositing or dumping large special type containers of a wide variety of styles.

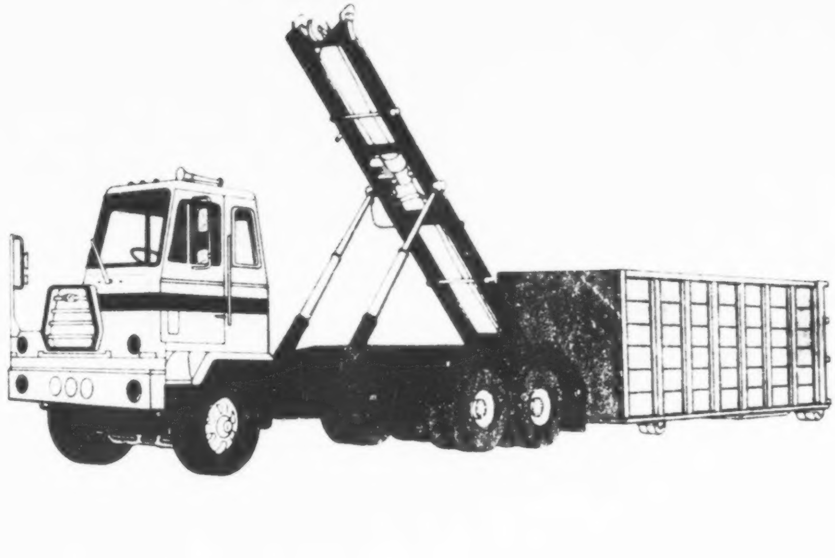
Although the Dempster Dumpster is available in several sizes and capacities the typical rig having lifting capacity of 9,000 pounds will readily handle containers varying in size from six to ten cubic yards. The approximate cost of this hoist, mounted on a suitable 24,000 pound GVW truck chassis costs approximately $11,000. The price of the containers varies from $900 to $1,000 each.

The Heil "Load Lugger", referred to above is available in several sizes. For handling six or ten cubic yard containers the manufacturer recommends a hoist model having a total lifting capacity of 20,000 pounds. Such a unit would be mounted on a 36,000 pound GVW truck chassis and would cost about $13,000. Six cubic yard closed containers are priced

CONTAINER REAR LOADING HOIST

at about $700. The ten cubic yard size would cost about $1,000.

Hoist, Tiltframe, Container, Packer: A tiltframe hoist is designed for attachment to a large truck chassis for the purpose of pulling a large container or body onto the chassis and allowing it to slide off at a desired location. They are used for loading, transporting, and unloading the large closed containers used with stationary packers and also for open top containers used to haul loose and uncompacted wastes to points of processing or disposal. In its simplest form, the tiltframe hoist is a heavy frame which is attached by a hinge at the rear of the main structural members of a truck chassis. The point of attachment will be about one fifth of the length of the tiltframe from the end which overhangs the chassis. A hydraulic ram-type lifting device is attached to the chassis and is capable of raising (tilting toward the rear) and lowering the frame and its load. A cable and winch are used to pull the container onto the tilted frame and to restrain it when being unloaded. Hydraulic stabilizing jacks are optional equipment available with most tiltframe hoists. Unlike rear loading hoists, which lift and swing loads onto the truck chassis, the tiltframe slides the container onto the truck by means of pulling cables. Exclusive of the truck chassis, list prices of tiltframes range from about $5,000 to $7,000. Several manufacturers of this type of equipment will be found in Appendix B.



CONTAINER PACKER TILT FRAME HOIST

Packer, Mobile: Mobile packers are of three general types, classified by the methods used to load them--from the side, rear, or front. When loose refuse is to be handled or trash cans are to be emptied manually it is common practice to use side or rear loading packers, although both can usually be fitted with lift mechanisms by means of which large containers can be lifted and emptied into the packer for compression. Front loading mobile packers are used exclusively to handle large containers mechanically. After wastes have been placed in the hopper of the packer or the container to be lifted, the hopper or the lifting mechanism is actuated and the loaded hopper or container is emptied into the body of the packer, where it is subsequently compressed to 20 percent or 25 percent of its original bulk. When fully loaded and with contents compressed, the packer is driven to a disposal area where the load is mechanically discharged from the body.

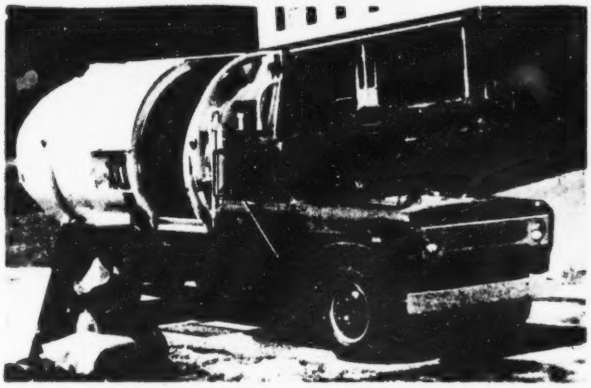
Mobile packers or compactors are available in a wide range of sizes from 13 to 28 cubic yards. A 31 cubic yard semi-trailer type is also available. It has its own self-contained power supply system for full operation.

There have recently appeared on the market small lift mechanisms capable of handling individual containers of about 80 gallons capacity.

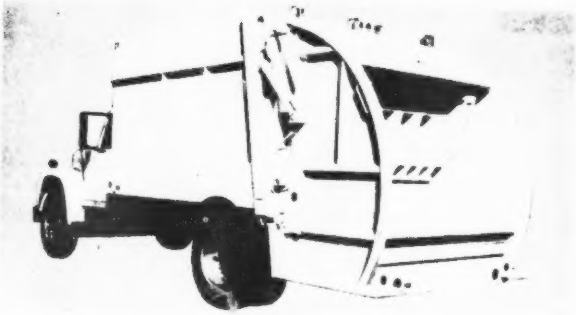
PACKER, MOBILE

Make	Model	Capacity	Power Plant Horsepower	Compaction Factor	TYPE Truck Mounted	 Trailer Mounted	Truck Size Required	Approximate Size feet	Approximate Weight lbs	Price	REMARKS
5000	---	5 cu yd	8	4:1	---	X	Pick up	12x5x7H	3800	$5,300	
5001	PR	10 cu yd	P.T.O.	NA	X	---	1 ton	12x8x9H	4000	*4,500	*With container lift. Side load-rear eject. Contailers available. Add $3,000 for 1 ton Truck
	PRP	10 cu yd	22	600#/cu yd		X	Pick up	NA	NA	6,000	Similar to Model PR.

* NOTE: Appendix B lists a number of manufacturers of mobile packers of larger sizes than the above.



SIDE LOADER



REAR LOADER

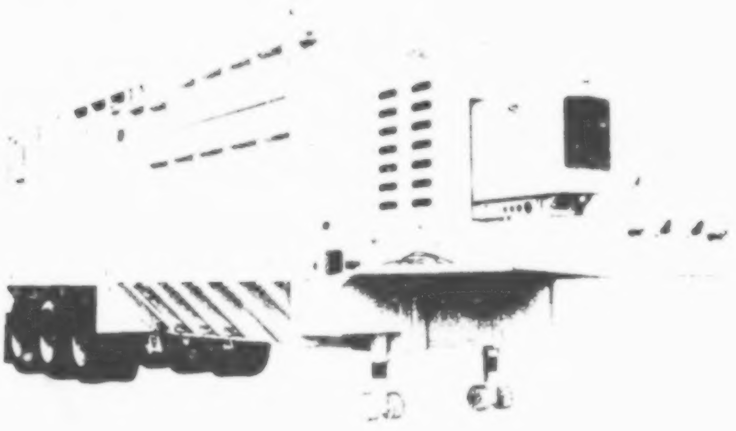
FRONT END LOADER

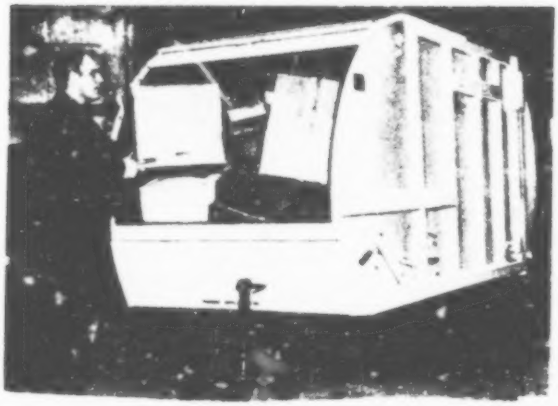
MOBILE PACKERS

These lift units can be attached to most conventional side or rear loading packers.

There are also available small sized mobile packers of 5 to 10 cubic yard capacities. These are quite suitable for use around housing complexes in conjunction with transfer stations and large stationary packers. Some of the models can be mounted on small trucks while others are designed to be trailed behind a pick up truck. Some details of the latter will be included on the section on trailer type packers.

Packer, Trailer: Appendix C lists several manufacturers of compaction trailers. This type of equipment consists of a complete packer and container mounted on a semi-trailer. These packers can be used in place of a stationary packer and/or a transfer trailer at a transfer station. Two sizes as manufactured by Dempster Brothers, Inc. are available--65 and 75 cubic yards. The trailer, with its compaction unit is 39 feet long, 8 feet wide, and from 12 to 13 feet high, depending upon the model. The hoppers of the two models will hold 16 and 19 cubic yards respectively. Gross weight of the vehicles is about 13 tons. The hopper opening is in the top of the box and is 100 inches by 88 inches in size. Materials can be dumped from other trucks or packers or chuted into the hopper of the trailer. Packing action is from front to rear. An 85,000 pound thurst is claimed. At the disposal site, the rear





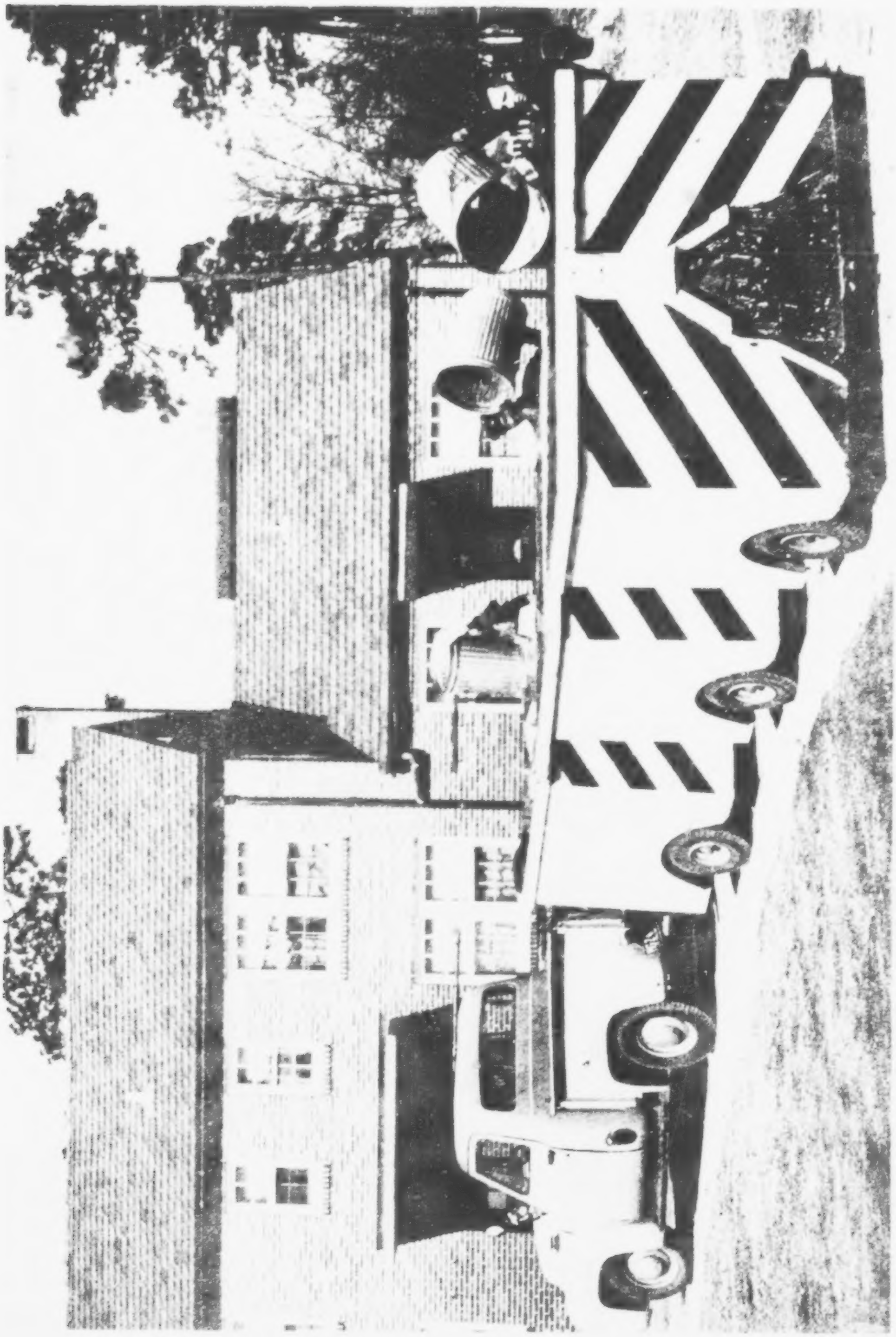
TRAILER PACKERS

tailgate of the trailer is opened and the load is pushed out through the rear.

The M-B Company and the Val-Jack Manufacturing Co., Inc. make small towable packers, referred to in a previous section, generally available in five cubic yard capacities. They may be either side or rear loaded. Their small size and easy maneuverability make them particularly adaptable for use where roadways are narrow and space limited. This type of packer is usually loaded and its hopper is low enough to allow refuse cans to be emptied into it with ease. The manufacturers claim compaction values of about 600 pounds per cubic yard for one of the self-powered trailer type packers.

Trailer models are priced from $5,000 to $6,000 for 5 and 10 cubic yard sizes. Ten cubic yards models to be mounted on trucks are $4,500 to $5,000. One ton trucks would cost about an additional $3,000.

Train, Container: Several manufacturers of this type of collection equipment are listed in the Appendix. Fairly typical of these are the Train Transfer System manufactured by LoDal and the Trux-"Train" manufactured by Truck Equipment Corporation. The LoDal system consists of two wheeled, open-topped containers of 4, 5, or 6 cubic yard capacities. Each container has its own nylon cover to prevent trash



CONTAINER TRAIN

from blowing about. A "train" consists of a light towing vehicle, commonly with four-wheel drive, and three containers which can be attached to each other. The containers can be lifted by LoDal's Load-A-Matic, front loading mobile packer. Prices of the containers vary from about $700 for the four cubic yard size to $800 for the six cubic yard size. A front end loading mobile packer, having a capacity of 25 cubic yards will cost about $14,000, truck chassis included.

The Truxmore Trux-"Train" usually consists of a light towing vehicle and either four 3 cubic yard two-wheeled containers, or three 4 cubic yard containers. These containers can be picked up by a Truxmore packer and emptied. The 3 cubic yard containers list at about $400 and the 4 cubic yard containers about $475. They weigh from 1,300 to 1,500 pounds each. A 23 cubic yard mobile packer to work with the Trux-"Train" would cost about $15,000, including truck chassis.

Although primarily intended for use in conjunction with a mobile packer these containers could, with some ingenuity be adapted to other unloading methods. An unloading ramp with a simple tilting mechanism could be developed so that loads could be dumped into stationary packer for subsequent processing and disposal.

Vehicle, Collection, Satellite: These small, powered collection vehicles are available in several models, including dump bodies of two different heights and capacities; flatbed; and pick up bodies. There is only one known manufacturer presently producing this type of equipment. Another maker has recently ceased production.

The dump type bodies come in 1-1/4 and 2 cubic yard, 1,000 pound capacities, and 1-1/2 cubic yard, 500 pound capacity. The former are standard dumping lifts which dumps 41 inches above the ground. The latter, elevated lifts, dumps at a height of 55 inches above the ground.

This type of equipment is used as satellite vehicle to service individual homes, as part of the total collection systems of some municipalities. Having a turning diameter of fifteen feet, the vehicle may be driven into residential driveways, turned around, and driven out again, thus eliminating the need to operate in reverse. Where backing is necessary, the driver has good visibility and, maneuve ing a small vehicle, the safety factor is favorably improved over that experienced with a large truck. After refuse from individual residential structures has been picked up, the satellite vehicle can rendezvous with a large mobile packer, into which it mechanically empties its load.

Within large housing complexes these vehicles could be used for building collection and then emptied into a mobile packer container or into a stationary packer hopper, by means of a dumping ramp, up which the vehicle could be driven. The unit is capable of negotiating steep grades, even when fully loaded.

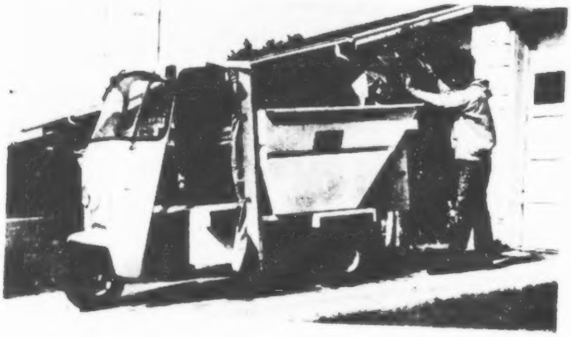
The power plant of these vehicles is an 18 horsepower, 2 cylinder horizontally opposed, air cooled, 4 cycle engine. The required hydraulic system operates from a power take off.

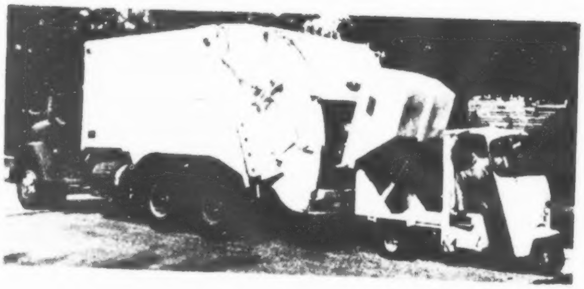
The manufacturer's claims of the overall economy achieved by the use of these satellite vehicles are based upon low first cost and capital investment; one man operation; rapid maneuvering; lower maintenance and mechanical operating costs. The manufacturer states that when the Cushman Haulster vehicles were put in use to provide back yard waste collection services in the City of Claremont, California that the costs for weekly pickups were reduced from $1.75 to $0.875 per house per month, a savings of 50 percent, while maintaining the same level of service that had been previously established.

VEHICLE, COLLECTION, SATELLITE

Make	Model	Hopper Capacity		Dump Lift	Overall* Dimension Inches	Net Weight lbs	Engine Horsepower	Turning Circle Diameter	Price	REMARKS
		cu yd	lbs							
12000	40571	1-1/4	1000	Stand.	115x46x41H	1130	18	15	$2,425	Also make flatbed models
	Mod. 612	2	1000	Stand.	115x64x41H	1207	18	15	2,500	
	Mod. 567	1-1/4	500	High	129x46x55H	1250	18	15	2,650	

*Cab height 70"
Add 5' to height for
body in dump position





SATELLITE COLLECTION VEHICLE

Storage Methods and Equipment

The storage of solid wastes, as the term is here used, is of a temporary nature and for a very limited period of time. The brief holding of kitchen and other household wastes is a varying necessity and every effort must be made to discourage or eliminate the attraction of insects, rodents, other vermin, or domestic animals and the reduction of noticeable odors. The covering of waste material storage receptacles and the sealing of any containers or packages of household wastes is essential to the health and well-being of residents and of the community but such covering or containment and sealing does not guarantee that insects or animals will not be attracted, but will act as a reduction of the degree of attractiveness which the wastes might otherwise have. Rigid plastic, covered containers or metal containers with tight fittings lids are not animal proof but are more resistant to attack than are paper or plastic-film type bags. A flexible paper or plastic bag, when properly sealed, and for such period as the bag remains intact will keep odors reasonably well contained.

The equipment included in this section varies from such simple devices as paper bags and plastic bags or container liners to large and semi-mechanical containers which are used in conjunction with and handled by mobile packers or compactors.

Bag, Paper, Disposable: These containers are made by a number of major paper companies, which also handle suitable holders or containers to facilitate the use of the bags.

The bags are usually made of heavy kraft paper. The papers have high wet strength and some are plastic-coated. They come in at least three classifications:

Standard - For general refuse, paper, glass, metal, plastics, bones, wire, etc.

Leak-resistant - For moist refuse, especially mixed materials, both wet and dry, as found in processing plants, food preparation areas, etc.

Leak-proof - For wet refuse, such as kitchen waste and other highly saturated materials. Holds garbage, liquids, wet trash--even coffee grounds, without leaking.

Capacities vary from 20 to 55 gallons with 30 gallons being the most common size. The dimensions of the 30-gallon bag are approximately 15" x 12" x 43". Those of the 24-gallon size are approximately 15" x 12" x 35". The bags can be closed by folding the tops and can be sealed either with tape or by stapling.

BAG, PAPER, DISPOSABLE

	BAG			HOLDER			
Make	Size gallons	Type	Price Per 100	Interior	Exterior	Price	REMARKS
3000	30	Standard	$14.00	X	X	$27.00	
	20	Leak Resist.	18.00	X	X	34.00	Swing-top lid
	30	Leak Resist.	19.00	X		8.00	Wall mounted
	20	Leakproof	21.00	X		16.00	Adjustable stand
	30	Leakproof	23.00			4.00	Casters for above
3001	30	Standard	16.00	X		9.00	Wall mounted, w/lid
	24	Standard	15.00	X		7.00	No lid
	30	Leak Resist.	22.00	X		14.00	Stand
	24	Leak Resist.	20.00	X		15.00	Adjustable stand
	30	Leakproof	29.00	X		4.00	Casters for above
	24	Leakproof	25.00	X	X	29.00	Cabinet w/lid
	30	Dry waste	12.00	X	X	50.00	Cabinet w/swing-top
3002	55	Standard	13.00	X		14.00	
	55	*Special	15.00	X		15.00	W/casters
	40	Leak Resist.	22.00	X		13.00	Wall mounted
	40	Leakproof	25.00				
3003	30	Gen. Purpose	16.00	X		9.00	Wall mounted
	30	Grease Resist.	18.00	X		13.00	Stand
	30	Heavy, Wet Waste	22.00	X	X	32.00	Cabinet w/swing-top
				X	X	56.00	Cabinet w/push-top

*Heat sealed

Prices per 100 bags range from \$14 to \$29 for the 20 to 30 gallon sizes, in small quantities. Prices can be expected to be lower by about 15 percent in large quantities.

Various styles of indoor and outdoor containers and holders are available from about \$8 for a wall-mounted holder to \$50 for a cabinet with a swing top lid.

Bag, Plastic, Disposable: The versatile plastic bag can be used either as a liner for a container, as a container itself, or as an emergency storage container. It is available in a variety of capacities from 20 to 55 gallons, with the 30 gallon size being most common. The latter size has dimensions of approximately 18" x 15" x 40".

This style container is resistant to tears but subject to puncture by sharp objects. Unless it is broken, it is leak-proof. Bags are available in packages of 100, 200, 300, 500, and 1,000 quantities and also in rolls. The roll-type bags are perforated in such a manner as to allow each bag to be torn from the roll when needed for use. Bags can be purchased at retail in very small quantities but the manufacturers and distributors discounts apply only in quantities of 100 or more, depending upon the size of the bags. In order to make prices comparable the tabulations are for packages of 100.

Prices for bags, in quantities of 100, range from about \$3.25

BAG, PLASTIC, DISPOSABLE

	BAG			HOLDER			
Make	Size Gallons	Price Per 100	Thickness (Mils)	Interior	Exterior	Price	REMARKS
4000	23	$ 4.23	1.4	X		$ 8.00	Wall mounted
	20	3.77	1.5	X		16.00	Floor stand
	32	5.03	1.5	X		19.00	Floor stand w/casters
	44-50	4.35	1.6	X	X	20.00	23 gallons - square
	20-32	4.50	1.6	X	X	35.00	50 gallons - square
	55	10.05	1.6	X	X	17.00	20 gallons - round
	30	9.95	2.5	X	X	22.00	32 gallons - round
				X	X	30.00	44 gallons - round
4001	20-30	3.24	1.2				
	31-32	4.76	1.5				
	40-45	6.72	1.5				
	55	10.44	1.8				
4002	30	7.36	1.25				

* Distributor Price

for the 20-gallon size to about $10 for the 55-gallon size or the 30-gallon size, made of heavier walled plastic. Larger quantity prices can be expected to be about 10 percent lower.

Various types of holders and containers are made for use with plastic bags or can liners. These are made to accommodate particular sizes of bags. They vary in prices from about $8 for a wall-mounted unit to $35 for a 50-gallon size cabinet suitable for either interior or exterior use.

Filled bags or liners can be easily closed and tied with special twist-type wires. This seals in odors and prevents the spillage of the contents. The bags are suitable for use as waste containers for curbside collection. The sealing of the bags does not provide a rodent or animal-proof container but the reduction or elimination of odors reduces their attraction.

The various manufacturers produce bags of varying wall thicknesses from 1.2 mils to 2.5 or 3 mils. Frequently the manufacturer specifies a range of thickness for a given bag (such as 2.14 to 2.61 mils) since manufacturing tolerances are not too exact. Manufacturers claim that the materials which go into the construction of the bags, rather than their actual thickness, govern their tear resistance and other desirable qualities. A range of bag wall thickness from 1.5 to 2.5

DISPOSABLE PLASTIC BAG

DISPOSABLE PAPER BAG

mils for sizes ranging between 20 and 55 gallons is suitable for average uses.

Barrel: Only barrels made of plastic, aluminum or fiber have been considered in this study. Steel barrels have not been included because of their weight and maintenance requirements.

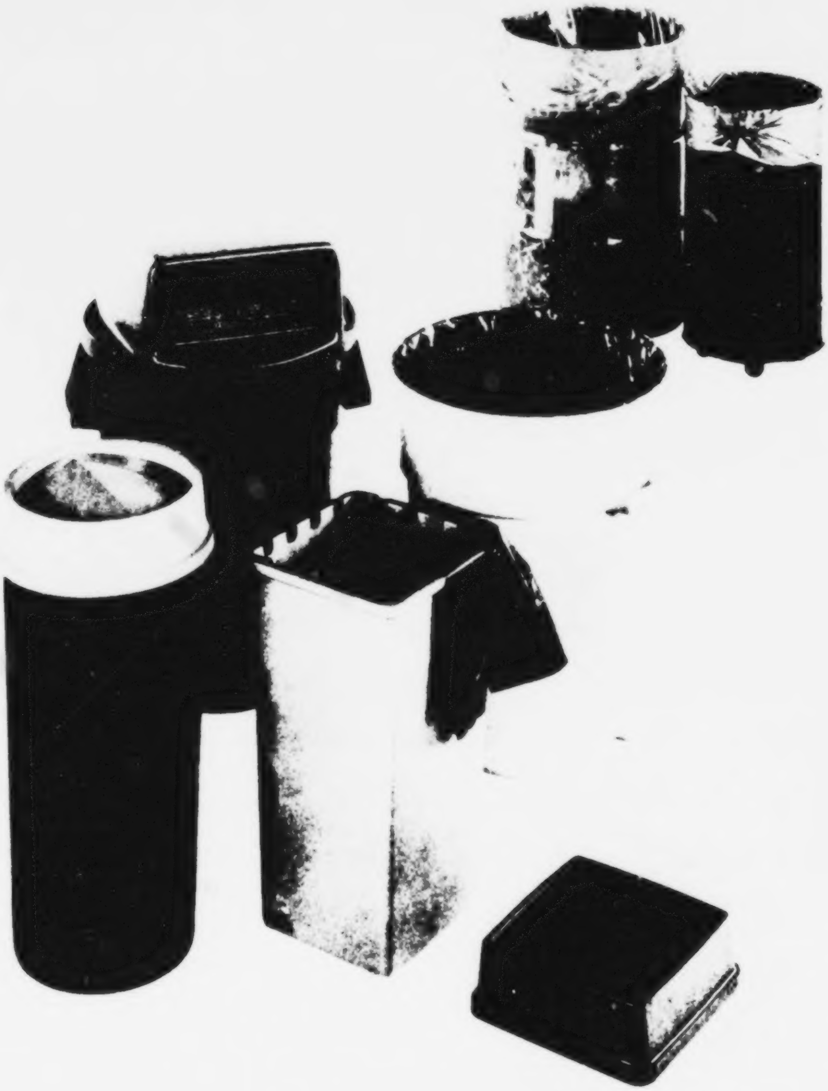
Fiber barrels are made from tough fibrous vulcanized materials. They will withstand rough, hard usage; are more suitable for indoor rather than outdoor use. In comparable sizes they are somewhat lighter in weight than either plastic or aluminum. They are slightly less costly than plastic but considerably cheaper than aluminum. They are available with lids, casters, and hand grips.

Aluminum barrels are made with 18 gauge sides and 14 gauge bottoms. Bottoms and the top rims are reinforced with ribs or bands. Rounded shoulder rests are provided in the bottom of the barrel. Seams are welded but handles are riveted on. Lids are not readily available in aluminum but the manufacturer states that aluminum barrels can be built to fit standard galvanized or plastic lids now on the market. The cost of these containers is about three times that of comparable capacity barrels made of fiber and about twice that of good grade plastic ones.

BARREL

Make	Approximate Capacity gallons	Size Av.Dia.x Hgt. inches	Approximate Weight lbs	Material	Handles or Grips	Colors Available	Wheels or Casters Available	PRICE*		REMARKS
								Barrel	Lid	
10000	60	27x30	10	Plastic	No	Orange only	No	$13.50	$4.50	
	80	33x30	15	Plastic	No	Orange only	No	18.00	5.00	
10001	35	NA	NA	Plastic	Optional	No	No	13.50	---	Tapered or straight
	45	NA	NA	Plastic	Optional	No	No	13.50	---	Tapered or straight
	60	NA	NA	Plastic	Yes	No	No	13.50	---	Tapered or straight
	32	NA	NA	Plastic	Yes	No	No	14.00	---	Tapered - Heavy side
	44	NA	NA	Plastic	Yes	No	No	21.00	---	Tapered - Heavy side
	60	NA	NA	Plastic	Yes	No	No	27.00	---	Tapered - Heavy side
10002	44	NA	14	Plastic	Extra Charge	Gray only	No	20.40	---	One year guarantee
	58	NA	16.5	Plastic	Extra Charge	Gray only	No	21.00	---	One year guarantee
	44	NA	12	Plastic	Extra Charge	Gray only	No	14.75	---	Six months guarantee
	58	NA	13	Plastic	Extra Charge	Gray only	No	15.50	---	Six months guarantee
10003	55	24x30	NA	Plastic	Extra Charge	No	Yes	17.50	4.50	
	65	24x36	NA	Plastic	Extra Charge	No	Yes	21.00	4.50	One flat side
	32	24x20	NA	Plastic	Yes (2)	No	No	15.00	4.50	
10004	20	20x23	6	Plastic	Yes	Yes	Yes	8.40	1.50	Dolly $12.30
	32	22x27	8	Plastic	Yes	Yes	Yes	12.40	2.40	Dolly $12.90
	44	24x32	14	Plastic	Yes	Yes	Yes	18.90	5.00	Dolly $16.90 (see also #14001)
10005	33	20x26	12	Aluminum	Yes	No	No	29.00	---	
	45	22x29	14.5	Aluminum	Yes	No	No	38.00	---	
	65	24x33	20	Aluminum	Yes	No	No	41.00	---	
10006	40	19x30	13	Fibre	Yes	Green/Brown	Yes	11.15	2.70	Casters $6.00
	49	19x36	14	Fibre	Yes	Green/Brown	Yes	12.10	2.70	Casters $5.85

*Minimum of 6 units.



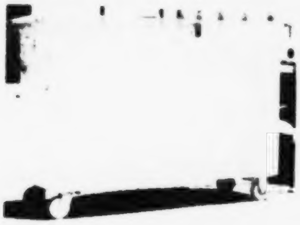
BARRELS

Plastic barrels are available in a wide variety of sizes. They are made with hand grips or handles. Casters or castered dollies are available, as are standard lids. Some manufacturers can provide barrels in a limited number of colors. Color-coded barrels could be used to aid in the segregating of wastes by either building occupants or maintenance personnel. Plastic barrels are competitively priced; are safe, silent, and easy to handle and have reasonably long life. Their availability in colors can be an advantage.

Cart, Hand-pushed: Carts are utilized in both storage and handling functions but have been included in this chapter on storage for purposes of this report. Many styles are available from the simple two-wheeled hand-truck for moving barrels to special purpose designs. Units suitable for handling solid wastes are manufactured with steel or aluminum frames and special purpose bodies are produced in aluminum, fiberglass, and stainless steel. Hamper-type carts of various sizes are also available with or without casters or bottom drain assemblies. Fiberglass carts or trucks are of the hamper or tub styles. Molded in one piece, of fiberglass reinforced polyester, they have smooth and seamless surfaces. They are non-rusting and are easily cleaned.

Hamper-type carts, fitted with swivel casters having 4-inch wheels are available in several sizes. A cart 36" x 26" x 27" deep

HAND PUSHED CART



STATIONARY PACKER CART

costs about $140. Cart sizes and costs of larger units range from upwards to 60" x 29" x 32" deep, costing about $250.

The relatively simple, two-wheeled hand cart is available in aluminum for approximately $40.

A relatively heavy-duty flat bed cart, with extendable ends will provide two additional feet of carrying space on each end of the cart, which is approximately five feet long without the extensions pulled out. Made of aluminum, it is lightweight yet has a capacity of approximately one ton. It is equipped with heavy-duty casters which make it steerable in four directions. This type of cart sells for approximately $350.

In between the hand carts just described and priced in the general area of $100 to $150 are a number of flat bed steel; steel and wood; or aluminum; or aluminum and wood combinations which are available.

Cart, Packer, Stationary: Although known as a cart, this device is a heavy-duty steel box which requires the use of a large special dumping device which, in turn, is attached to a large capacity stationary packer. The cart is castered and may be drawn or pushed by some type of towing unit or tractor. It can be coupled with similar carts and thus made into a train. They are made in sizes ranging from three to five cubic yard capacity, but usually the three or four cubic yard sizes are used with a five cubic yard stationary packer. The three cubic yard size will cost approximately $400 and the four cubic yard size about $425.

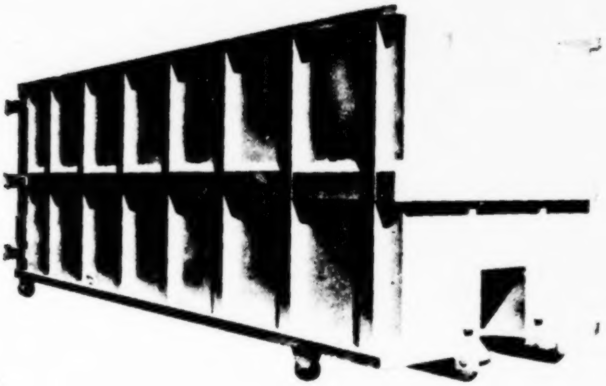
In use, these containers require a special type of dumping device which permits them to be pushed onto a platform either at ground level or at truck height. The dumper, when actuated, lifts and tilts the container, which is securely latched onto the dumper platform, and empties it into the charging box of a stationary packer. The ground level model of this dumper costs approximately $2,500. The dock type dumper requires a special metal ramp and costs approximately $2,100.

Container, Open-top, Roll-off: Built of heavy steel, substantially reinforced, these containers are designed for the mechanical dumping of loose wastes and very large, generally non-compactable objects. They are frequently used in connection with self-dumping hoppers handled by forklifts.

Capacities of these containers range from six to forty or more cubic yards. Overall widths are about eight feet. Heights vary from three to eight feet. Lengths run between 17 to 21 feet.

These big boxes are handled onto and off truck chassis by tiltframe hoists of various designs. Dumping the contents of the container is accomplished by raising the box and opening its rear doors.

Prices on the largest size are not available, but $400 for the



ROLL-OFF OPEN TOP CONTAINER

10-yard size and $700 for the 20-yard container will provide some basis for estimates.

Container, Packer, Mobile: Containers used with mobile packers vary in sizes, shapes, and styles, depending upon the type of packer they are to be used with, the manner of dumping, and the manufacturer. The three general classifications of mobile packers, front-loader, rear-loader, and side-loader, require containers of similar characteristics and these are identified by the same descriptive nomenclature. Containers having from one to six yard capacities are in general use. Some special industrial styles are somewhat shallow pan shaped and may hold up to 12 or 15 cubic yards. The mobile packers which handle and dump these containers are equipped with special hoists and their several methods of use are described in detail below.

This class of container is made by many different manufacturers and used with a variety of front-loading packers. The descriptions and comments that follow are general in nature and represent a somewhat composite picture of available equipment. Generally rectangular in shape and holding from one to eight, or in some cases ten cubic yards, these containers are intended for the temporary storage of loose wastes. They may be chute loaded under certain conditions but are usually filled by hand or from hand pushed carts. They are commonly placed on the ground and left in such a position that packers may be easily maneuvered into position for the pick up of the container by the trucks' loading mechanism. They are used extensively as parts of store, shopping center, apartment, and institutional waste collecting systems. The pick up and emptying operations are handled by municipal or private hauling contractors' crews. After emptying into the mobile packer, the container is replaced on the ground for reuse.

Containers are equipped with hinged covers to prevent deposited refuse from being scattered by the wind. Some covers are spring loaded. The smaller sizes of containers are usually castered to allow for hand pushing. This is especially so where they are for use inside buildings where headroom and/or other clearances will not allow trucks to reach the usual locations of the containers. Where loading docks are available, the larger sizes of containers are feasible. They can be placed on the ground and loading from hand pushed carts can be accomplished from the dock level.

The designs of loading lugs and container shapes vary with the different manufacturers. In general, the lifting mechanism is a forked arrangement and requires matching slots or holders on the sides of the containers.

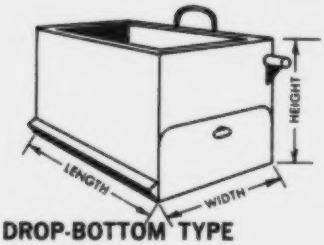
Front loader packers, and hence the containers used with them, have the advantage of requiring less handling labor since the truck driver has a much better view of the container to be lifted than he does with rear-loading packers. The front-loaders are usually operated by the driver, but in congested areas where maneuverability and vision is limited a helper is required. Rear-loaders require a minimum of two men and commonly three make up a crew.

Prices of these containers will vary, depending upon design, weight, and corresponding delivery costs. However, they will generally be found in the following range: 1 cubic yard at $150; 2 cubic yards at $195; 3 cubic yards at $245; 4 cubic yards at $275; 5 cubic yards at $320; 6 cubic yards at $345; and 8 cubic yards at $415.

There are fewer types of rear-loaders designed to handle containers than there are front loaders and, hence, there are a limited number of sizes and styles of rear loading packer containers available. Shapes vary from generally rectangular, with sloping fronts for smaller containers, to large, somewhat shallow pan styles on the 10-15 yard sizes. Like the front loader containers, these are equipped with hinged tops, some being spring loaded. The smaller sizes are usually caster mounted.

The side loading packer container serves in much the same manner as does the front loader container. Two general styles are common. One has a flat top while the other is slightly peaked. Both are equipped with lids. Sizes range from 1-1/2 to 4 cubic yard capacities. Containers are castered and the manufacturer claims ease of handling and spotting. Weights of empty containers range from about 300 to 600 pounds.

Container, Rear Loading: These containers differ greatly from those used with mobile packers and are not to be confused with them. These units are large special purpose containers, frequently used in industry. Open topped, tank type, and other styles of closed containers are available. They are equipped with special lifting ears or lugs and can be handled only by the special hoists (described earlier under the heading: Hoist, Container, Rear Loading). The rear loading container is lifted by the special hoist, which is usually mounted on a short wheel heavy duty truck chassis. It can then be transported and subsequently deposited or dumped at a disposal site. Containers are generally of two basic types--tilt and skip, or bottom dump. In addition to styles already mentioned, hopper, sludge, and pallet styles are available. Although, as previously mentioned, these containers are used in industry for hauling bulk materials, they have applications for moving wastes around building complexes and can be chute or mechanically loaded.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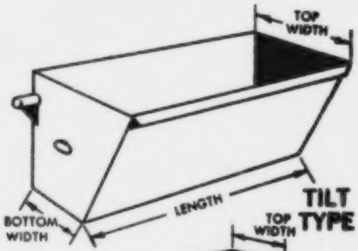
DROP-BOTTOM TYPE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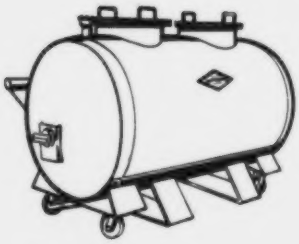
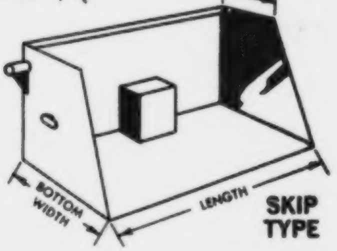
TILT TYPE



TANK CONTAINERS
from 250 to 1,200 gal. cap.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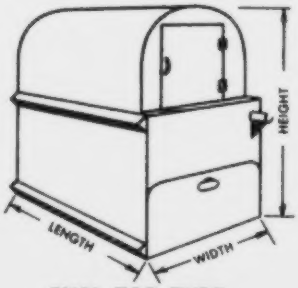
SKIP TYPE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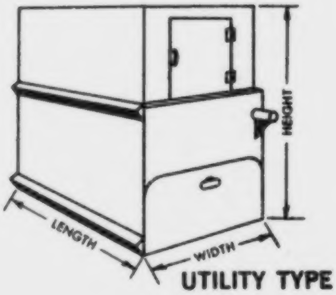
OVAL TOP TYPE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UTILITY TYPE

REAR LOADING CONTAINERS

Rear-loading containers come in several sizes ranging from one to ten cubic yards. The four most popular sizes and their approximate costs are:

Two cubic yards	$185
Four cubic yards	$325
Six cubic yards	$400
Eight cubic yards	$500

Container, Receiving, Packer, Stationary: Unlike containers used with mobile packers, of which there are a variety of shapes, those used with stationary packers are more uniform in general configuration. These containers, generally box-like in appearance, usually have an opening in the lower half of one end of the box to allow the packer ram to operate inside the container during the compaction cycle. This loading end is also hinged as a tailgate to permit it to swing fully open for the dumping of refuse from the container at the point of disposal. The container is equipped with a pair of cables which are used to retain the compacted load during transport to the disposal area.

The stationary packer is equipped with a ratchet locking device used to secure the container to the packer during the filling and compacting operations. When the container is full, the ram has been entirely withdrawn and the retaining cables or tubes and the tarpaulin are in place, the full container is winched onto a tiltframe hoist and can be carted away. The full container is replaced by an empty one, which is strapped or locked to the packer and the entire unit is again ready for operation. The sides and top of the container are tapered slightly to facilitate refuse slideout when dumping. The following data will indicate the price range of the various sizes of containers available:

Capacity (cu yd)	Length (feet)	Approximate Price
27	16	$3,000
30	18	3,100
37	20	3,400
42	22	3,500

Container, Standard, Household: The most commonly used storage container for residential wastes are plastic or galvanized metal containers or barrels in sizes which vary from 20 to 30 gallons. The heavy-duty varieties of these containers are listed under the heading of "Barrels". The lighter weight containers are readily obtainable by the householder in such retail outfits as supermarkets and hardware stores. They are relatively inexpensive and range from $2 to $4.

Processing Methods and Equipment

Under this heading are the many kinds of equipment designed to change the original size, shape, volume, density, or other general characteristics of solid wastes generated in residential complexes. Some of these devices and mechanisms have sufficient abilities to handle industrial castoffs as well. Included are machines for the reduction in size and nature of tree, shrub, and yard trimmings; the crushing of glass and metal containers; grinders and shredders capable of reducing general wastes to flaked or particle form; and pulpers which employ hydraulic shear to reduce wastes to a slurry for pipeline transport and ultimate treatment. The processing considered here is intermediate, rather than final. The latter will be covered elsewhere.

The nomenclature of this type of equipment sometimes may be confused with equipment previously reviewed due to the similarity of titles. In general, these machines are intended to change or destruct a variety of materials. Among them are industrial components which can be adapted to the processing of solid wastes. These include grinders, shredders, hoggers, crushers, and pulverizers. Some crushers are known as hammermills by their makers while other similar machines may be called grinders or pulverizers. Hoggers are frequently known by a variety of names, largely related to the type of material which they are called upon to handle. A volume could be written upon this subject of confusing and overlapping nomenclature but limited space here will not allow complete elaboration. Suffice it to say that awareness of the existence of this condition is important and that sometimes only the fineness of the end product may change the name of the device.

The selection of intermediate processing equipment will be greatly affected by the hourly or daily volumes of wastes to be handled. Some of the equipment discussed cannot be practically used unless volumes are large and the rate of flow is reasonably uniform. Still other types require the almost steady attention of trained personnel. Certain machines, although quite safe in general operation, present some possible accident dangers unless provided with safeguards against improper and unauthorized use.

Several of the devices described can be adapted to a chute-fed operation and can be semi-automated so as to minimize the amount of human attention necessary. Still others require such attention at the start and/or completion of the processing operation. Some of the balers and compactors are in that category.

Baler: This type of compacting equipment reduces the original loose volume of compressible materials fed into it and produces a dense compact package of manageable size and weight. Some finished bales are bound with metal strapping, wire, or twine; others are retained in a plastic bag or a corrugated board box which may be bound by restraining strapping or wires.

There are many styles and kinds of balers; some portable but most stationary. Again, as with such equipment as compactors and grinders, crushers and shredders, there is ambiguity in nomenclature. For the purposes of this report the following terms are used to identify compacting devices:

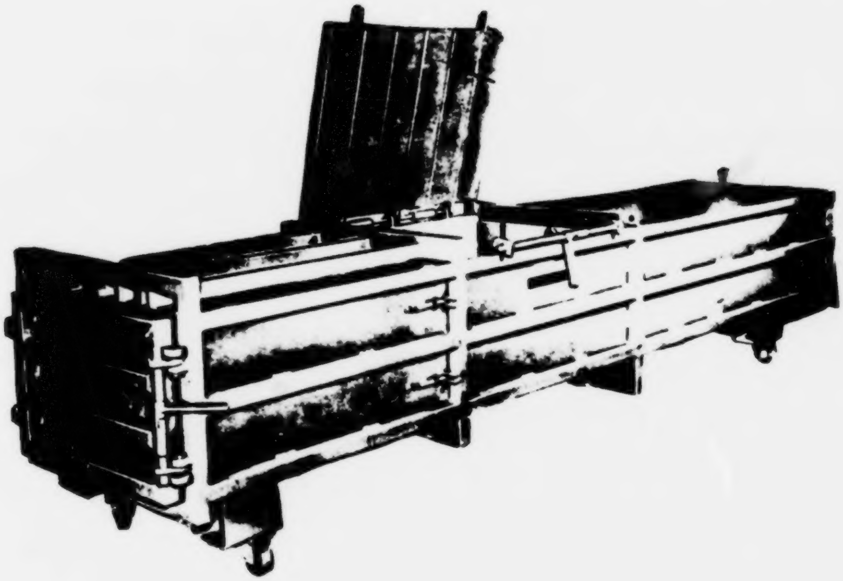
Type	Restrainer
Baler, Portable	Wire, twine, or strapping
Baler, Stationary	Wire, twine, or strapping
Compactor, Bag	Plastic bag
Compactor, Console	Plastic bag or corrugated box
Compactor, Rotary	Plastic or paper box
Compactor, Stationary	Steel box
Compactor, Undercounter	Paper bag

Each type will be discussed under its most commonly accepted name.

Baler, Portable: These balers are of two principal types: horizontal, mounted on casters; vertical, mounted on pneumatic tires and towable.

The horizontal types have gross weights between 3/4 and one ton. They will range in size upward to 10 feet long x 3 feet wide and 3 feet high. They produce bales which must be tied with twine or bound with wire or metal strapping. Bales will be between 10 and 15 cubic feet in volume and weigh from 100 to 300 pounds, depending upon the nature of the contents. These balers are powered by electricity and usually manually operated and are not normally chute-fed.

The vertical type portable baler is a self-contained baling press mounted on four pneumatic tires. It weighs about 3 tons and must be towed. A small gasoline engine provides the power for the hydraulic operating system. The baler is 13 feet high, 12 feet long, and 8 feet wide. The manufacturer's brochures do not give the size of the bales produced but state that the equipment is "producing bales weighing up to 1,000 lbs or more." Bales must be bound with wire. The equipment is manually operated and does not appear to be adaptable to chute-feeding. Balers of this type are made by Maren Engineering Corp. and the Tamaker Corp. Prices of horizontal type balers range from about $2,500 for the smaller machines to about $12,000 with those having a greater capacity. Portable machines cost about $5,500.



PORTABLE BALER

Baler, Stationary: Balers are made in a wide range of sizes and types but only the smaller ones are considered in this section of the report. Included in the tabulation are machines capable of producing bales weighing from 150 to 800 lbs or more; and having volumes from about 6-1/2 to 35-1/2 cubic feet.

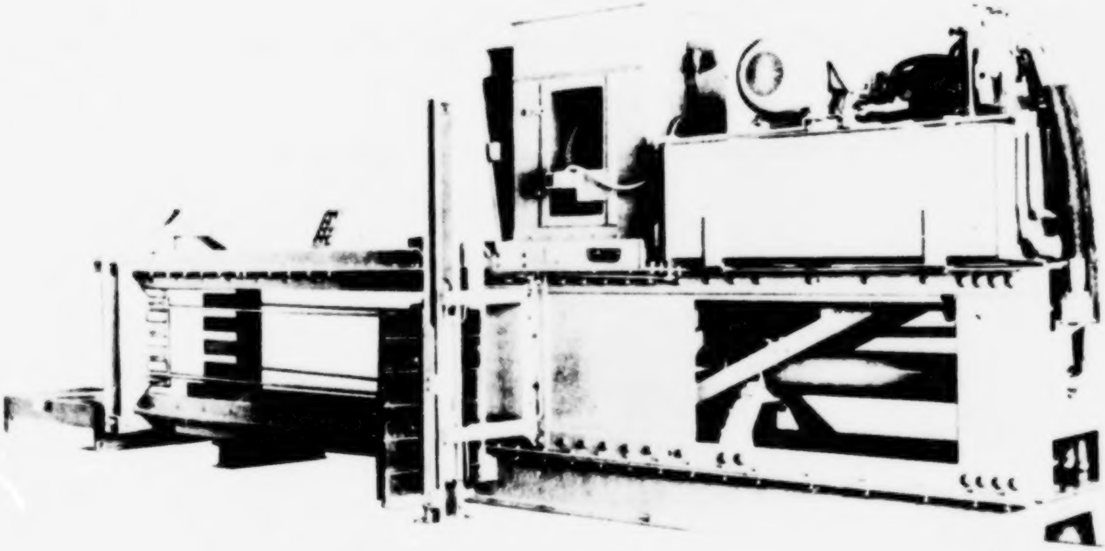
The compaction ratios shown in manufacturers' data sheets cannot be implicitly relied upon. Obviously, the composition of the materials making up bales of refuse will vary greatly. Bulk reduction of three or four to one normally can be expected. Based upon a density of 6 pounds per cubic foot for loose wastes as adopted for purposes of this report, the density of compacted wastes can be expected to be about 20 pounds per cubic foot. Relating this factor to the baler capacity, a small baler of say 6-1/2 cubic feet would contain about 130 pounds of compacted wastes or the average daily waste production of about 43 persons per bale based upon a daily per capita production of 3 pounds. Ultimate capacity of the baler, of course, is largely dependent on the frequency of service that is practical by maintenance personnel.

Some models, being chute-fed, are quite fully automatic, requiring an attendant's time only to fasten restraining wires and remove the bale. Other types must be hand fed and although less expensive than the chute-fed models, require more operational manpower. The size

BALER, STATIONARY

Make	Model	Overall Dimension Inches	CONTAINERIZED PACKAGE				Claimed Compaction Ratio	Compaction System	Horsepower	Price	REMARKS
			Weight Lbs	Size Inches	Volume cu ft	Density Per cu ft					
15000	PT-1C30	106x65x82H	150	30x16x24	6.7	20-24	6-8:1	Hydraulic	5	$6,400	(see also #6000)
	PT-11	41x30x94H	150	30x16x24	6.7	20-24	6-8:1	Hydraulic	3	2,700	
	PT-12	48x30x94H	225	36x20x24	10.2	20-24	6-8:1	Hydraulic	5	3,100	
15001	LHD-36	53x29x95H	175-300	36x20x20-30	8.4-12.5	20.8-24.0	NA	Hydraulic	3	2,100	
	LHD-45	62x40x100H	300-600	45x24x22-34	13.7-21.2	21.9-28.3	NA	Hydraulic	5	2,600	
	LHD-54	72x41x121H	350-800	54x27x23-42	19.5-35.5	17.9-22.5	NA	Hydraulic	7-1/2	4,900	

NOTE: The above data and claims are those presented by respective manufacturers.



STATIONARY BALER

of the bales produced by some models will permit the enclosure of the bale in a plastic bag to reduce nuisance from odors and to reduce the attraction of flies and rodents.

Balers do not lend themselves well to the handling of excessively wet wastes. Bagged or loose wastes can be handled by this equipment. If salvage of wastes is to be achieved, then selective segregation must be practiced, prior to baling. In municipalities utilizing incineration or sanitary landfill for disposition of solid wastes, the baling of residential refuse can provide a satisfactory processing method, but some cities require that baling wire be cut at the disposal site.

Chipper, Brush: These machines are designed to reduce brush, tree limbs, and cuttings to shredded material by passing the debris through a rapidly revolving drum equipped with cutters. The brush or limbs are hand fed into a receiving hopper at the back of the machine. The revolving drum pulls the material through the cutters and the resulting shredded wood and leaf particles are blown through an inclined delivery tube into a truck. The chipper is usually towed by the open truck used to haul the shredded materials to a disposal point. Models with 12- and 16-inch wide drums and cutting knives are available. The rotors are driven at 3,000 rpm by heavy duty industrial type combustion engines.

The approximate cost of a 16-inch machine is $4,200. A machine with the 12-inch drums and cutting knives would be somewhat less.

Collector, Dust: Several varieties of dust collectors are made. The least complicated is the bag type, of which there are variations such as shakerless and intermittent types. The basic type forces dust-laden air upward through a series of cylindrical bags. The air passes through the walls of the bags and into the clean air manifold, leaving the dust deposited on the inside surfaces of the bags. The bags are periodically shaken by pneumatic or electrical mechanical devices. The dust falls into a hopper and is usually removed by a screw conveyor. The shakerless collectors rely upon reverse air flow for cleaning. This type has fewer moving parts. The intermittent collector is similar to the basic type but must be periodically shut down for shaking.

The centrifugal collector employs a series of clusters of dual vertical cylinders, one inside the other. Dirty air is forced in a downward spiral in the circumferential space between the outer and inner cylinders. The dust is collected in a hopper at the bottom of the cluster, while the cleaned air is exhausted upward through the inner cylinder. The dust is removed from the hopper by air.

Collectors operating on the cyclone principle consist of a circular outer cone of high velocity air and an inner column of swirling rising air. At the lower end of the funnel, a partial vacuum exists. The dust-laden air enters the collector tangentially and follows a spiral pattern to the bottom of the cone. The centrifugal action, which forces the heavier dust particles to the periphery of the collector increases as the velocity increases and the radius of the vortex is reduced. This combination of gravitational and swirling forces causes the dust to move downward to the dust outlet. The cyclone collector has many applications to waste systems and is available in a number of sizes and capacities.

Cyclonic separators are rated by air volumes and unless details of a specific installation were known it is not possible to make more than the roughest kind of estimate of cost. For a cyclone capable of handling the dust and particles from a paper hogging and baling operation of medium size might run about \$3,000. In addition there might be from \$1,000 to \$3,000 cost of connecting piping and incorporation of the cyclone into the system where it is to be used.

Cyclonic separators are used in waste processing installations such as hogging or shredding operations and in pneumatic waste conveyor systems.

Compactor, Bag: A wide variety of this type of equipment exists, some of it proven by use but other makes and models that are barely beyond the conceptual stage. Variations among types are:

Horizontal ram	Vertical ram
Single bag	Continuous, multi-bag
Pre-shredding	Available accessories
Optical controls	Sonic controls

One manufacturer combines a shredder with the compactor and has a line of accessories which include a rotary or carrousel platform, stationary bag holder, large detachable container, and a conveyor for handling continuous multibags.

Bag type compactors can be chute-fed and manufacturers claim productive capacities of equipment ranging from 7 to 44 cubic yards per hour. The production of any of these machines is dependent upon the time and attention given by building personnel. Single bags must be removed when full and replaced by empty ones; continuous, multibags must be tied off, removed, and replaced; filled castered containers must be replaced, all of which emphasizes the necessity for matching equipment to anticipated daily volumes and the availability of maintenance personnel.

Compaction ratios from 4:1 to 8:1 and package densities from 18 to 60 lbs per cubic foot are claimed by manufacturers dependent upon the composition and mix of solid wastes which will vary over a wide range. Based upon a density of 6 pounds per cubic foot for residential wastes as adopted for this study and a realistic compaction ratio of 3 or 4 to 1, a density range of 18 to 24 pounds per cubic foot may be expected. Containerized packages weighing as much as 200 lbs, as claimed for one model, present handling problems which may require the use of more than one man for their removal and transport.

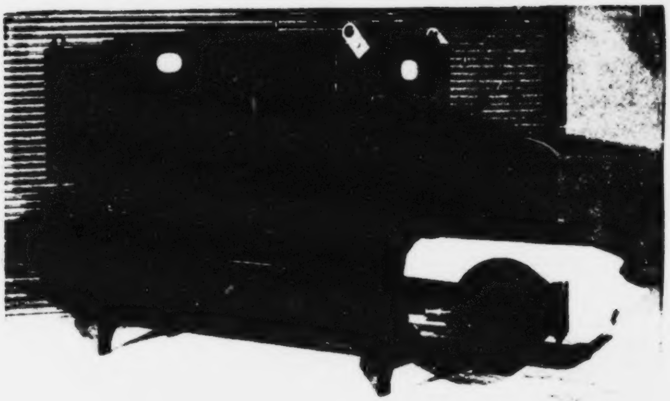
A compactor which combines a shredder is a recent addition to the line of pulverizer-extruder equipment made by one manufacturer. The descriptive information provided by the maker is sketchy and vague and its usage in service is presently limited.

A variation of conventionally designed bag packers has a duplex ram. A smaller diameter independently operated ram is built into the center of the main ram. Three hydraulic pistons actuate the rams--two for the main ram and one for the secondary ram. The device has a cone on its output snout. The primary ram compresses the waste materials into the larger portion of the compression cone, after which operation the secondary ram is actuated, thus further compacting the refuse and forcing the compacted materials into a receiving bag or can.

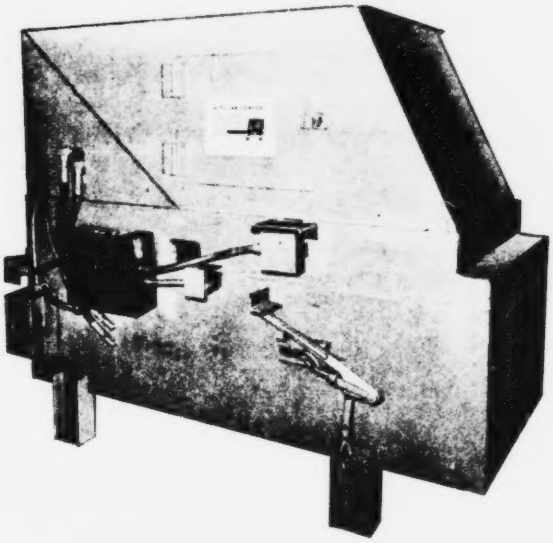
COMPACTOR, BAG

Make	Model	Overall Dimension Feet	CONTAINERIZED PACKAGE			Packer Face Pressure psi	* Claimed Compaction Ratio	Volume Per Hour cu ft	Horsepower	Price	REMARKS
			Approximate Capacity	Approximate Weight	Density Per cu ft						
7000	16	13x3x6H	30 gals	100 lbs	50-60 lbs	293	8:1	450	3	$3,800	Single bag (see also #9000)
	20	13x4x7H	55 gals	200 lbs	50-60 lbs	187	8:1	960	3	4,600	Single bag
7001	900	7x3x4H	NA	NA	NA	NA	8:1	216	7.5	4,700	Continuous, multi-bag, combined with shredder. Can eject into packer container (see also #8001 and #11000)
7002	---	8x4x7H	3.5 cu ft	60-90 lbs	18-27 lbs	NA	NA	NA	7.5	5,300	Continuous, multi-bag
7003	BC-16	NA	3.5 cu ft	55-110 lbs	Varies	NA	5:1	NA	NA	3,500	Single bag (see also #9002)
7004	48-02	8x3x4H	NA	NA	NA	NA	NA	1200	NA	NA	Single or multi-bag
7005	---	8x2x10H	3.5 cu ft	40-100 lbs	12-38 lbs	NA	7:1	Varies	3	4,500	Special paper bags - 9¢ each

* Compaction ratios are those claimed by the manufacturers



BAG COMPACTOR



STATIONARY COMPACTOR

Paper bags of the "sausage link" type are available. These are made with 10 "links" and are stapled in such a manner as to permit longitudinal expansion as the links are filled. The machine extrudes the compressed wastes in slugs, into the attached string of bags. The bags can be conveniently tied off, cut apart and thus become individual units which can be conveniently handled. The manufacturer claims over 300 installations in the first two years of marketing. Most of these machines serve high-rise apartment buildings in New York City.

Compactor, Console: This class of equipment employs a vertical compacting ram, which may be either mechanically, hydraulically, or air operated and is usually hand fed. Chute-fed models are in the development and testing stage. These units compress waste into a corrugated box container or a plastic or paper bag.

Models are available to process one container or two containers side-by-side, but housed within the same cabinet. There are also available in-line type compactors, some of which will accommodate up to eight containers, but these are not within an enclosed cabinet and are not intended for operation by building tenants as are the two previously mentioned ones. The containerized packages are about 3-1/2 cubic feet in volume but models by one manufacturer produce packages of from 5 to 6 cubic feet. The densities of containerized packages range between 12 and

30 lbs per cubic foot. Claimed compaction ratios run as high as ten to one. One type provides for the suspension of the receiving bags from special holders mounted on a castered cart. This permits the filled bags to be transported within a building without need for a separate cart.

The claimed weight of containerized packages ranges from 40 to 120 lbs. It is estimated that a single unit would handle the daily wastes of up to 40 persons (based upon a per capita production rate of 3 pounds per day) before a full bag or container would have to be removed from the machine and be replaced with an empty one. The capacity of the unit is limited by the frequency of service furnished by maintenance personnel.

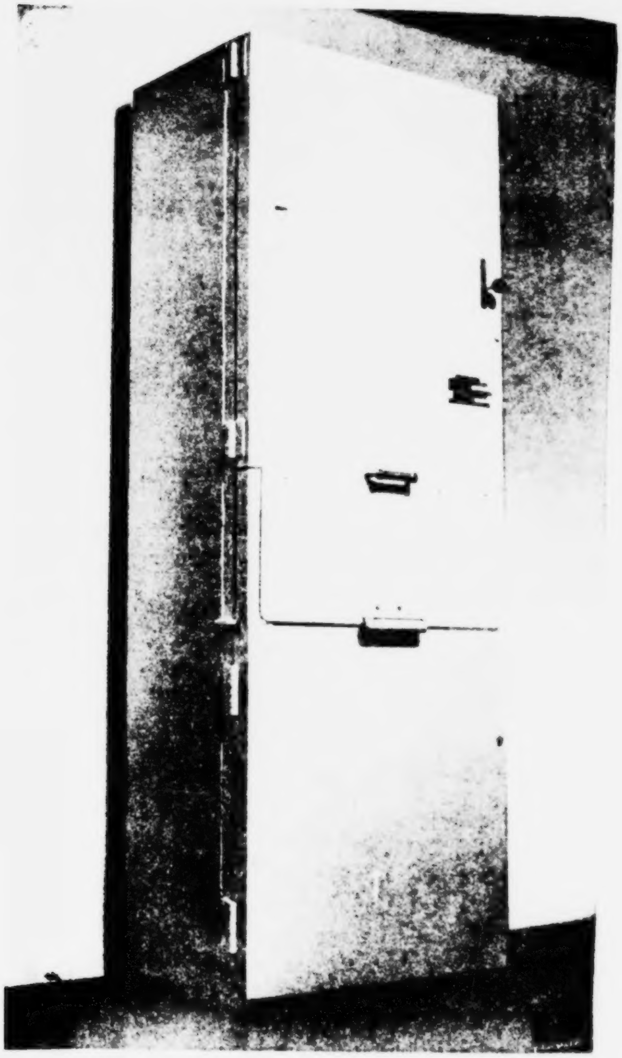
This type of compactor can be chute-fed, but such adaptation generally is considered practical for only low density housing because of the small capacity of this type of machine, between servicings, or where frequent service is feasible.

The first compactor of this type was developed in Sweden and several hundreds are reported to be in use in Western Europe. This same machine and other types developed by the same originator are now being made and marketed in the United States. At least two somewhat similar lines of compactors have been designed by U.S. manufacturers.

COMPACTOR, CONSOLE

Make	Model	Overall Dimension Inches	CONTAINERIZED PACKAGE				* Claimed Compaction Ratio	Compaction System	Horsepower	Price	REMARKS
			Weight Lbs	Size Inches	Volume cu ft	Density Lbs per cu ft					
6000	100	30x28x65H	60-100	16x24x18-26	4.0-5.8	12-20	10:1	Worm Drive	3/4	$1,000	Package height can be preset (see also #15000)
	ST-1	29x20x81H	100	16x24x27	6.0	16-20	10:1	Hydraulic	1-1/2	2,750	
6001	1-1000	30x24x77H	40-75	17x14x26	3.5	11-21	NA	Air	5	2,750	One-bag model
	2-1000	41x24x77H	40-75	17x14x26	3.5	11-21	NA	Air	5	3,600	Two-bag model

* Compaction ratios are those claimed by the manufacturers.



CONSOLE COMPACTOR

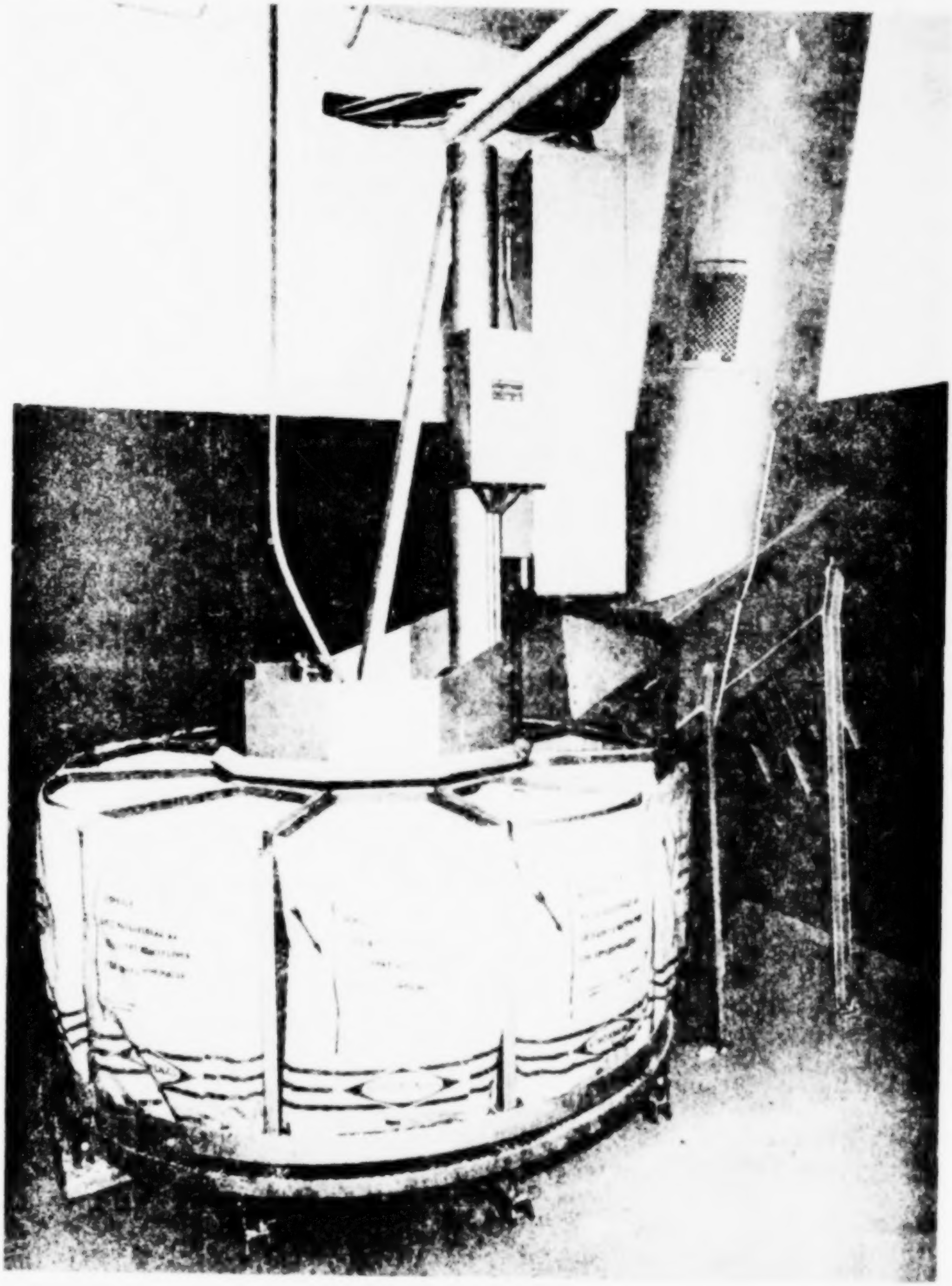
This method for compaction and packaging of solid household and institutional wastes is semi-automatic in operation, but does require attention by building personnel. Such attention may be once or twice daily, or more frequently under certain conditions. The equipment can be provided with alarm devices to notify an attendant when bags are full or the machine malfunctions. No unusual or expensive equipment is needed to handle the containerized waste. One man can easily transport the packaged material on a two-wheeled hand truck and this material can be transported over the road in pick up trucks or larger flatbed trucks.

Compactor, Rotary Type: This style of compactor sometimes called a carrousel type, consists of a ram mechanism which packs loose wastes into paper or plastic bags held in open positions on a rotating platform. When the bag directly under the packing ram is filled to a predetermined depth, the platform indexes one position, thus moving the full bag from under the ram and replacing it with an empty one. The bags are held in place within a compartment which confines the bag and prevents it from rupture during the packing cycles. These compactors are made in standard models of 8 or 10 bag compartments but are available to accommodate 20 or 30 bags. Originally of Swedish design and manufacture, they are now being made and marketed in the United States.

COMPACTOR, BAG, ROTARY

Make	Model	Overall Dimension Inches	CONTAINERIZED PACKAGE				* Claimed Compaction Ratio	Compaction System	Horsepower	Price	REMARKS
			Weight Lbs	Size Inches	Volume cu ft	Density Per cu ft					
8000	500-8	55x55x79H	60-70	16x17x27	3.5	17-20	NA	Air	3	$4,700	Eight-bag, chute fed (see also #6002)
	500-10	66x66x79H	60-70	16x17x27	3.5	17-20	NA	Air	5	5,300	Ten-bag, chute fed
	800-10	65x65x82H	60-70	16x17x27	3.5	17-20	NA	Air	5	5,800	Ten-bag, chute fed
	1150-10	65x65x90H	60-70	16x17x27	3.5	17-20	NA	Air	5	9,300	Ten-bag, chute fed with hopper
8001	900	84x33x48H	NA	Varies	NA	NA	8:1	Mechanical	7.5	6,500	Shredder-compactor. Converted by adding carousel bag carrier (see also #7001 and #11000)

* Compaction ratio as claimed by the manufacturer.



ROTARY TYPE COMPACTOR

The advantages of multibag machines are obvious. Each bag will hold about 3-1/2 cubic feet of compacted wastes, estimated by the manufacturer to have a density of up to 20 pounds per cubic foot. It is estimated that a ten bag compactor can handle the refuse generated by 200 to 250 persons for each servicing. Removal and replacement of bags can be accomplished in less than an hour by one man.

Rotary compactors having at least eight-bag capacities can be used in multistory low density residential structures. They can be chute-fed and can readily be equipped with optical or sonic controls.

Another manufacturer markets a carrousel device holding several bags. The bags are held in their open position and the waste, having been previously shredded by related equipment is dropped into them. The manufacturer's data sheets are in preliminary form and detailed information is not available. This equipment was also mentioned in the section on bag type compactors.

Compactor, Stationary: The stationary compactor is quite frequently known as a stationary packer. Both manufacturers and users employ the terms interchangeably. In its fairly standardized form it is a compaction unit having a hydraulically operated ram which moves in a

COMPACTOR, STATIONARY

Make	Model	Charge Box Cap. cu yd	* Volume per Hour cu yd	** Claimed Compaction Ratio	Maximum Force lbs	Packer Face Pressure psi	Overall Dimension Inches	Price	REMARKS
9000	1850 Stand.	0.33	31.0	10:1	15,000	21.0	71x43x70H	$2,800	2 cu yd rear loading container $300
	1830-2000	0.30	39.6	↓	25,000	46.5	68x43x70H	3,300	2 cu yd front or loading container $300
	1830 Super	0.35	46.0	↓	25,000	46.5	68x43x70H	4,000	2 cu yd front or loading container $300
	DP - 18	1.8	155.4	↓	39,000	38.7	100x66x60H	4,500	60" height without hopper
9001	SP-5-20	0.6	---	5:1	20,100	23.3	44x84x45H	3,000	3 cu yd container $400
	SP-10-42	1.2	87.6	↓	42,400	29.9	52x98x52H	3,400	10 cu yd container $1100
	SP-42-50	2.1	118.2	↓	50,900	28.0	182x98x62H		Containers available to 45 cu yd
	SP-42-90	2.8	259.2	↓	91,800	38.8	183x98x62H		Containers available to 45 cu yd
9002	Apartment			4:1	7,300	21.3	72x40x57H	4,000	With one container (see also #7003)
	1 FLPC	1.0	61.8	5:1	25,000	27.4	NA	5,000	With one container
	2 FPC	2.0	139.2	↓	40,000	22.2	NA		
	3 FPLI	3.0	138.6	↓	56,500	31.2	NA		
9003	P - 811	1.0	27.6	NA	28,000	32.0	NA	NA	
	P - 10	2.3	146.4	↓	56,000	40.0	NA	NA	
	P - 40	2.7	202.2	↓	90,000	50.0	NA	NA	
9004	B - 101	1.3	63.6	4:1	42,300	33.0	132x67x45H	NA	
	B - 102	2.3	140.4	↓	57,500	32.0	148x67x53H	NA	
	B - 103	3.6	213.6	↓	88,000	49.0	184x67x53H	NA	
9005	LSP - 10	NA	103.8	5:1	39,000	30.0	120x60x54H	4,000	6 cu yd containers $640

* Loose Volume.

** Compaction ratios furnished by manufacturers did not identify variations in the composition of wastes.

horizontal direction. Wastes are fed into a receiving hopper and the ram, when actuated, either manually or by optical or sonic devices, compresses the wastes into a steel container which, although an important part of the equipment, is a separate component which can be easily attached to or detached from the packer mechanism. The filled container, if small, can be moved by hand on its casters. The larger capacity containers must be handled mechanically by special types of equipment as discussed previously.

The stationary packer is a proven type of solid waste processing equipment. It is capable of reducing wastes to 20 percent-25 percent, or less, of their loose volume. Charging box capacities of these packers range from about one third of a cubic yard to several yards. Packer capacity is rated in cubic yards per hour and is dependent upon charging box capacity and cycling time. Chute feeding is a common practice when these packers are used. Optical and sonic controls are available to provide automatic operation, which requires only periodic attention of maintenance personnel.

Containers for use with packers are made in various sizes. They are provided with casters and are usually fitted with lifting sockets which allow them to be mechanically lifted and emptied by a front or rear loading mobile packer. This labor saving procedure is all too frequently impeded or ignored by building planners who fail to provide adequate maneuvering space, headroom, and accessibility from the exterior of the building. It is interesting to note that except for only one known manufacturer these containers are interchangeable with the various makes of mobile packers. In a few instances some modifications of the lifting sockets must be made on the containers.

This type of compactor--because of its large container capacity, requires less frequent attention by building maintenance personnel. The smaller sizes can be fitted with containers varying from 2 or 3 cubic yard capacities upward. This improves maximum capacities from 50 percent to 100 percent over bag type compactors. Attendants' time is correspondingly reduced.

Prices of these compactors range between $3,000 and $5,000, depending upon size. Containers cost from about $300 for the two yard size to over $1,000 for the ten yard size. Compactors are available from more than ten manufacturers and the list of container makers is even longer.

The selection of the proper size compactor and containers will be governed by the number of persons to be served in a given residential building. It is also possible that compactors of this type, which can also be manually fed, might be located as a central processing and storage area in a housing complex.

Compactor, Undercounter: About two years ago, a small compactor for individual residences was introduced in test markets. It was designed as a free standing appliance or could be installed under the work counter in the kitchen or in a utility room. It occupies 2-1/4 square feet of floor space and is less than 3 feet high.

The lower portion of the compactor is a drawer, into which a special paper bag is fitted for receiving kitchen wastes and refuse. The drawer is pulled out and wastes may be dropped into the bag. The drawer is then closed, causing the deposited wastes to be automatically sprayed with an odor reducing solution. When the drawer is fully and properly closed, a starting button is pushed thus energizing the compacting ram mechanism. Two power screws operate the ram, which is said to transmit 2,000 lbs of force to a ram plate of 6" x 12" or an equivalent pressure of about 28 psi to the loose refuse in the drawer. Bulk reduction ratio of four to one is claimed by the manufacturer. The energizing button can be locked out with a special key to prevent tampering by children. The maker states that "almost all household items can be put in the unit, including bottles, cartons, food wastes, and aerosol cans."

The resulting "package" measures 9" x 16" x 18", contains 1-1/2

COMPACTOR, UNDERCOUNTER

Make	Model	Overall Dimension Inches	CONTAINERIZED PACKAGE				Claimed Compression Ratio	Compaction System	Horsepower	Price	REMARKS
			Weight Lbs	Size Inches	Volume cu ft	Density Per cu ft					
13000	SVC-80	24x15x35H	20-30	9x16x18	1.5	Varies	4:1	Mechanical	1/3	$ 230	Bags cost 33¢ each

cubic feet of compacted wastes and is said to weigh between 20 and 30 lbs, although a dealer admits that 30 lbs is not unlikely. Using the production factor of 3 lbs per capita as adopted for purposes of this report, then the compactor would serve a family of 4 for about 3 days before the package need be sealed and removed for disposal. However, the manufacturer claims that test market data indicates that a family of four averages only one bag per week, when excluding deposit of magazines and papers.

The current list price of the machine is about $230 to $250. A discounted price of about $170 is indicated by the manufacturer for large quantity purchases by housing developers. The odor reducing aerosol sells for about $1 per can. With normal operation, about 3 cans per year are required. Bags cost about $3.60 per dozen. It is reasonable to assume than an average of 1-1/2 bags might be required per week for a family of four persons. This could conceivably mean an addition to the operating cost of the equipment of about $25 per year.

The compactor was developed jointly by a large household appliance manufacturer and a major mail order and retail merchandiser. Marketing is presently through the stores of the merchandiser and the dealer outlets of the manufacturer. Due to the short history of this unit, sales and user experience, factual data on capacity, life expectancy, and maintenance problems are limited.

Crusher, Bottle, and Can: These machines come in several models. Some crush only bottles, other flatten cans, while the larger models can handle both bottles and cans. The latter may be equipped with a sloped conveyor to carry the materials to be crushed to the top of the machine. The crushing principle involves the use of three horizontal drums revolving in close proximity to each other. The drums have intermeshing vee-shaped protrusions which force the cans or bottles between the rollers. The manufacturer claims a size reduction ratio of ten to one. Prices range from about $900 for a small combination crusher to about $3,300 for a large capacity machine equipped with a conveyor.

Grinder, Dry: Trade nomenclature for this type of equipment is highly variable. Unlike pulpers, garbage grinders, and related types, this equipment does not require a substantial flow of water for proper operation. For the purposes of this study, dry grinders include machines sometimes known as hoggers, pulverizers, grinders, shredders, hammermills, etc. Three somewhat distinctive types will be discussed.

Though almost unknown outside of the wood and paper industries, the wood hog effectively reduces fibrous as well as friable materials. It will readily shred logs, railroad ties, paper, and plastics. It shatters and granulates glass and similar materials and destroys metal

GRINDER, DRY

Make	Model	Claimed Reduction Ratio	Claimed Density lbs/cu ft	Volume Per Hour	Overall Dimension Inches	Motor Horsepower	Price	REMARKS
11000		15:1	24-93	15 cu yd	78x61x70H		$14,000	With input screw conveyor and accessories. Includes hammermill and compactor. Produces very dense slugs. (see also #7001 and #8001)
11001	100	4:1	---	to 5 tons	88x58x99H	100	19,500	
11002	HD-17-F-18		---	to 5 tons	76x59x69H	100	6,500	Blow-hog with 40" fan and motor.

containers efficiently. A version of this shredder combines a wood hog with a powerful blower, thus providing air transport for the processed materials. The shredded materials can be removed from the airstream by a cyclonic separator. Municipal and institutional wastes have been successfully handled by such a blow-hog system. The final product can be emptied into large packer containers or blown into an incinerator.

Another type of dry grinder manufactured by Eidal International Corporation employs a vertically rotating assembly. A series of stacked star gears revolving loosely about vertical axes are mounted on this assembly. The case housing the assembly is tapered, with its narrower section at the bottom. The interior of the case is lined with heavy grinding plates. The material to be processed is introduced at the top and falls downward between the outer grinding plates and the revolving cutter assembly. Larger articles are crushed at the top of the grinder and, becoming smaller, are eventually shredded by the lower gears. The equipment has been successfully used to shred apartment, institutional, and municipal wastes.

Mil-Pac Systems, Inc. markets a vertically shafted hammermill to shred or grind solid wastes. The material can be reduced to such size that, by the addition of a very slight water spray, it can be compressed and extruded as a dense briquette. The manufacturer claims a 15:1 bulk reduction ratio. Solid wastes can be chute-fed to the machine or an inclined screw conveyor can lift the waste material for deposit in the top of the machine.

Consideration of the use of any of the described dry grinders must take note of their relatively high noise factors. Installations must be remote from living units or located in sound insulated equipment rooms.

Grinder, In-sink: Although their use is banned by some cities, New York being an example, in-sink garbage grinders are reliably reported to be installed in over twelve million kitchens throughout the United States. Made by at least a dozen manufacturers and sold under numerous labels, 60 to 75 models are available, ranging in prices from less than $25 to $150.

These waste food processors are designed to reduce wet garbage to particles small enough to be flushed into a sanitary sewer line. They are of two general classes; continuous-feed and batch-feed. In the former, as the name implies, wastes can be continuously fed into the grinder while it is operating. It is controlled by a wall switch. The latter type is fed in batches and is controlled by its stopper, which actuates an electrical switch when in the closed position. Batch types are considered safer to operate and are usually slightly higher in cost

GRINDER, IN-SINK

Make	Model	Size or Capacity	Horsepower	Feed	Reversing Switch	Impeller Blades	Price	REMARKS
1000	300	1 Qt	1/3	Continuous	NA	Swivel	$ 24	Service motor
	400	2 Qts	1/3	NA	NA	Swivel	32	Induction motor
	500	2 Qts	1/2	Batch	NA	Swivel	45	Sound shield
	600	2 Qts	1/3	NA	NA	Swivel	43	Custom switch cover
	700	2 Qts	1/2	NA	NA	Swivel	53	Deluxe model
1001	NPD-100	1-1/4 Qts	1/3	Continuous	No	Swivel	40	Made by #1002 as "Budget" model
	NPD-200	1-3/4 Qts	1/2	Continuous	Yes	Swivel	60	Made by #1002 as "Feature" model
1002	KWF-100	2 Qts	1/2	Continuous	Automatic	Fixed	80	Rotation reverses with each start
	KWD-100	2 Qts	1/2	Batch	Automatic	Fixed	100	Rotation reverses with each start
	KWI-100	2 Qts	1/2	Continuous	Automatic	Fixed	130	Rotation reverses with each start
	KWS-100	2 Qts	1/2	Batch	Automatic	Fixed	150	Rotation reverses automatically if machine jams
1003	2000	2 Qts	1/3	Continuous	No	Swivel	25	Top Control Kit ($12) converts any model to batch feed
	2700	2 Qts	1/3	Continuous	No	Swivel	NA	
	2900	2 Qts	1/3	Continuous	No	Swivel	NA	
	3000	2 Qts	1/2	Continuous	No	Swivel	32	
	6300	2 Qts	1/2	Continuous	No	Swivel	45	Sound insulation
	8000	2 Qts	1/2	Continuous	No	Swivel	55	Sound insulation
	9000	2 Qts	1/2	Continuous	No	Swivel	70	Sound insulation
1004	40	1-1/2 Qts	1/2	Continuous	No	Fixed	*29	
	50	1-1/2 Qts	1/2	Batch	Automatic	Fixed	*50	Sound shield. Reverses if jammed
	60	1-1/2 Qts	1/2	Continuous	Automatic	Fixed	*45	Sound shield. Reverses if jammed
	80	1-1/2 Qts	1/2	Batch	Automatic	Fixed	*63	Switch cover plate. Reverses if jammed

GRINDER, IN-SINK (con't)

Make	Model	Size or Capacity	Horsepower	Feed	Reversing Switch	Impeller Blades	Price	REMARKS
1005	33	10#/hr	1/3	Continuous	No	Adjustable	$ 120	
	50	15#/hr	1/2	Continuous	No	Adjustable	NA	
	75	20#/hr	3/4	Continuous	No	Adjustable	NA	
	100	25#/hr	1	Continuous	No	Adjustable	NA	
1006	KD-30	NA	1/3	Continuous	Yes	Fixed	30	All models made by #1007
	KD-50	NA	1/2	Continuous	Yes	Fixed	35	
	KD-55	NA	1/2	Continuous	Yes	Fixed	44	Heavy duty motor. Sound insulated
1007	BB - 30	NA	1/3	Continuous	Yes	Fixed	**23	
	BB - 50	NA	1/2	Continuous	Yes	Fixed	**26	
	BB - 55	NA	1/2	Continuous	Yes	Fixed	**30	
	BR - 55R	NA	1/2	Continuous	Automatic	Fixed	**35	Rotation reverses with each start
	GB-559	NA	1/2	Continuous	Automatic	Swivel	**44	Hammen turn 360°
1008	77	NA	1/2	Continuous	Automatic	Fixed	78	Rotation reverses with each start
	707	NA	1/2	Continuous	Automatic	Fixed	89	Rotation reverses with each start. Sound Insulation
	17	NA	1/2	Batch	Automatic	Fixed	92	Automatic Rotation Reverses
	107	NA	1/2	Batch	Automatic	Fixed	104	Automatic Rotation Reverses. Sound Insulation
	555	NA	1/3	Continuous	Automatic	Fixed	50	Economy model - 3 years parts protection
	333	NA	1/3	Continuous	Automatic	Fixed	31	Economy model - 1 year parts protection
1009	FC-100L	½ Qt	1/3	Continuous	NA	Fixed	43	8000 rpm
	FC-400L	1 Qt	1/3	Continuous	NA	Fixed	61	8000 rpm
	FC-500L	1 Qt	1/3	Continuous	NA	Fixed	NA	8000 rpm
	FC-600L	2 Qts	1/2	Continuous	NA	Fixed	NA	1725 rpm
	FA-600L	2 Qts	1/2	Batch	NA	Fixed	86	
	FC-800L	2 Qts	1/2	Continuous	NA	Fixed	97	
	FA-800L	2 Qts	1/2	Batch	NA	Fixed	113	

* Special builders' prices for "Breakthrough" only.
**Contractors' volume costs.

than the continuous feed types.

Impellers are of two general types: Fixed blade and swiveled hammer. At least one manufacturer makes a version of the fixed blade impeller to permit adjustment for wear of the blades. The swiveled hammer type has less tendency to jam in use than the fixed blade impeller. It is more desirable provided that the rivets which serve as hammer axles are strong enough to withstand long usage.

Some makes and models are equipped with a device which will automatically reverse the rotation of the impeller if it becomes jammed. Several others are wired so as to reverse or alternate the rotation of the impeller at each start of the grinder. Machines having fixed blade impellers and which are not equipped with some convenient means of reversing their rotation electrically are subject to jamming and may prove to require frequent service.

It follows that price is an important factor in the selection of any equipment, particularly of a type such as the in-sink garbage grinder, which is attached to the household plumbing system. Low initial price may mean higher maintenance costs and shorter life. The so-called "list prices" of garbage grinders can be quite misleading and are almost invariably subject to appreciable discounts, even when only one grinder is bought.

This equipment has a useful life expectancy of ten years, when properly used by the householder and when furnished with either a motor overload protective device or reversing switch to prevent jamming of the unit with non-grindables. Some form of sound shielding should be provided. Parts which are particularly subject to corrosion should be made of resistant materials such as stainless steel or plastic. Coatings are subject to scratching and abrasion and do not provide adequate long time protection. A grinder should be capable of satisfactorily reducing to small particles such wastes as citrus rinds, corn husks, and bone scraps, as well as the more common items generally found in household garbage. Ease of connection, disconnection, and general accessibility to the mechanism for servicing should have prime consideration, as should the availability of parts and qualified maintenance service.

Hogger: The hogger fits into that gray area which has been previously discussed where nomenclature confuses rather than enlightens. The hogger can be generally classified as a dry grinder, which has been previously covered in this report, but at the risk of some possible reiteration a brief discussion on related equipment follows. Under the general heading of destructive mills are hammermills, grinders, crushers, hoggers, and pulverizers--all of which belong to the same family group. The action of these mills is to shatter friable materials by impact as opposed to grinding them between two harder objects or materials. There are many types of mills available, some with fixed hammers or swinging hammers and still others are equipped with knives. It is to the latter group that the hogger belongs.

The hogger is classified by some manufacturers and users as a hammermill and it may also be correctly classified as a shredder. It was originally designed to break up wood scraps for further processing, easier disposal, or for fuel. This particular type of mill is frequently referred to as a "wood hog." The predominating design feature is that of a hammermill, although some hogs are made with knives instead of hammers. The hammer type hogger is generally classified as knifeless.

Another type of hogger is known as a "blow hog." A blower is incorporated into the design of a system which provides for the pneumatic transfer of the chopped up or shredded materials through tubes or conduits. This type of system has many industrial applications and has been adapted to the destruction and handling of solid wastes by the Jacksonville Blow Pipe Company, makers of the Montgomery "Blo-Hog." This system includes a cyclonic separator which deposits the shredded wastes into a receiving hopper.

Incinerator, Package: The discussion of incinerators will be limited to those types of equipment which are most applicable to the problems with which this report is concerned and will include the smaller capacity equipment, those usually identified as package and on-site incinerators. A review of the Standards of the Incinerator Institute of America (See Appendix D--Classification of Wastes and Incinerators) is essential to the proper selection of equipment of this type.

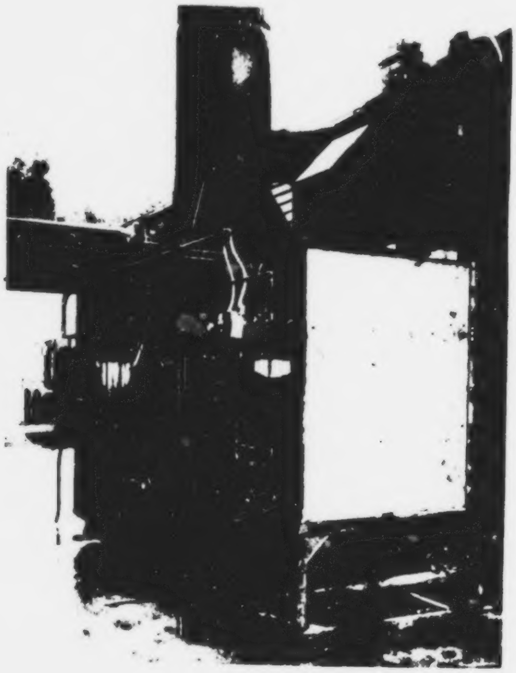
Typical of the conventional package incinerators marketed for on-site installation is the 600 lbs per hour retort incinerator as manufactured by Sargent NCV Division, described below.

The R 600-1 incinerator is classified as a heavy destructor of the retort type capable of handling Class I or Class II wastes. The manufacturer claims it meets the standards of the Incinerator Institute of America for this type of equipment and complies with the requirements of Class III, Class IV, Class VI, or Class VII incinerators. Advantages claimed for retort type over in-line incinerators include substantial space savings due to reduced length of the retort equipment and some increase in burning efficiency of this type of unit. The R 600-1 retort incinerator requires a space of about 13'-0" x 9'-0" with about 14 feet of vertical clearance. The unit is 7'-6" high without allowances for stack connections. The cost of this unit is about $8,000 f.o.b. plant excluding installation.

The gas scrubber unit (model 600) for this incinerator is of the wet impingement type and has a capacity of 6,480 lbs of gases per hour, at temperatures up to 2,000 F. This equipment requires 6 gallons of water per minute at 30 psi. Standard models include stainless steel inlet sections with alloy steel outer shell. However, complete stainless steel construction should be specified for acid or pathological wastes. Space requirements will vary slightly depending upon whether the scrubber is equipped with either a top or side inlet, but generally a space 8'-0" x 6'-0" with 13 feet of vertical clearance will accommodate either model. Approximate cost of the model 600 scrubber is $4,500. Other accessories such as a pyrometer and control panel are priced at $150 and $500 respectively.

Small incinerators used for the processing of residential wastes require little fuel use beyond the start-up time. The nature of residential solid wastes, with a relatively high content of readily combustible materials, will continue to support combustion once the load is well ignited. Where available, gas is a commonly used fuel for start-up and to assist in the burning of extremely wet wastes, but some incinerators may be equipped to burn fuel oil.

The above described equipment is typical of the smaller package incinerators which are presently available from several manufacturers.

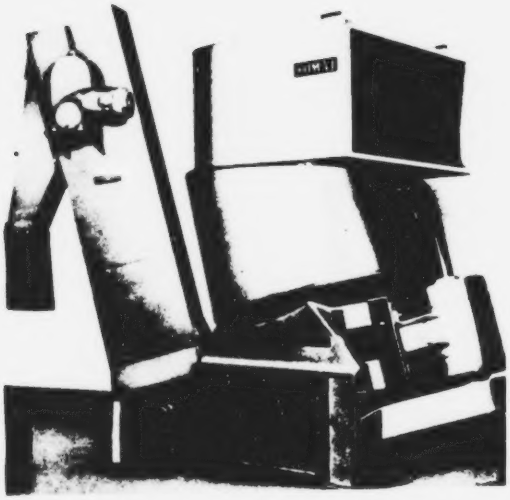


PACKAGE INCINERATOR

Manufacturers of small incinerators that meet the emission standards in the Code of Federal Regulations are listed in Appendix E. Improvements in this type of equipment over the years have been largely confined to design changes of components, such as the shape of combustion chambers, kinds of refractory linings, methods of introducing and controlling combustion air, modification of afterburner principles, and other air pollution control devices. Advances have also been made in the design of stacks, stoking methods, and ash removal. The development and installation of automated controls have improved the operation of small on-site incinerators. In short, incineration is a highly complex process. Increased automation and decreased human interference have improved this waste reduction method and decreased resulting environmental pollution. The design of installations cannot be left to catalogue selection of equipment nor can proper evaluation of problems and their solutions be left to the layman. It should be stressed that qualified engineers experienced in incineration design should establish criteria and supervise the necessary plans, specifications, and operating procedures for any type of incinerator installation.

Pulper: There are several solid waste processing systems on the market and in operation which utilize pulpers as the principal means of reduction. Generally, pulpers consist of a pulping bowl with a pulping impeller and a waste sizing ring in the bottom. Accessory equipment includes a junk ejector and a dewatering press. The pulper and junk ejector are mounted directly adjacent to each other but the dewatering press may be located at some distance from the pulper and connected to it by piping. It is possible to utilize multiple pulping stations and one dewatering press and in general, units can be located in the most convenient places since the slurry goes to the press and water is returned to the pulper by pipelines. Wastes can be introduced into the pulper by chute in floor models, manually fed into pit models, or carried by belt conveyor into these or other models. Capacities of pulpers vary from about 1/2 to 2 tons of waste per hour.

In general, where only food wastes, paper, and light residential or institutional wastes are being processed, the equipment is reported to perform satisfactorily. During the development stages of some of these pulpers, considerable difficulty was encountered in the satisfactory handling of plastics, especially including polyvinyl-chloride containers, plastic tubing and some of the occasional heavier materials which are found in unselected wastes. The Somat Corporation and Wascon Systems, Inc. have produced standard models whose design was originally based upon



PULPER WITH AUTOMATIC JUNK EXTRACTOR

the requirements for the pulping of solid wastes in institutions but which, of course, would also handle residential wastes. The Somat Corporation estimates that water requirements for their pulpers is based generally on 20 to 25 gallons per 100 pounds of dry solid wastes processed. Through the use of dewatering devices the majority of water used is reclaimed and recycled in the pulping operation. It is not possible to obtain firm figures on the cost of this equipment since an appreciable portion of such costs is for installation.

Since all installations must be designed to fit particular problems and buildings, the manufacturers are reluctant to provide cost estimates or guidelines.

The Black-Clawson Company, designers and manufacturers of pulpers and other specialized equipment for the paper making industry, have recently introduced a system utilizing pulping as its operating principle. This firm's experience with heavy duty pulpers has given their waste reduction system some desirable features which appear to have improved the ability of a waste pulper to handle heavier and more dense materials. The manufacturer claims that tests already made indicate the hydrapulper can handle the full range of plastics and unselected residential wastes.

An important element in the satisfactory performance of this equipment is attributed by the manufacturer to the type of rotor and extractor bed plate used in the pulper. It is of a design which has been modified from the heavy duty equipment which has had years of continuous operation in the paper industry. Limited experience indicates that this pulper can satisfactorily handle the high density materials found in general solid wastes. The statement has been made by the manufacturer that the pilot plant has successfully pulped--among other things, small animals; garden trimmings, including branches and leaves; wire bound crates; and 2" x 4" lumber.

This sytem uses a junk ejector to remove large particles of metal, glass, and other unpulpable materials. These are deposited in containers for separate disposal. The slurry is piped from the hydrapulper to a dewatering press and the resulting residue or sludge is deposited as very moist, shredded material in containers for later disposal. It could be thoroughly dried to save transported weight or disposed of moist in a sanitary landfill, according to current practices.

The pilot plant was observed in operation at Middletown, Ohio. A large pile of freshly collected municipal garbage and refuse was available for testing purposes. The various materials were fed into the pulper bowl, using a portable belt conveyor. Observations indicate that all wastes were adequately pulped. Only a small percentage of the input was rejected as unpulpable and removed by the junk ejector.

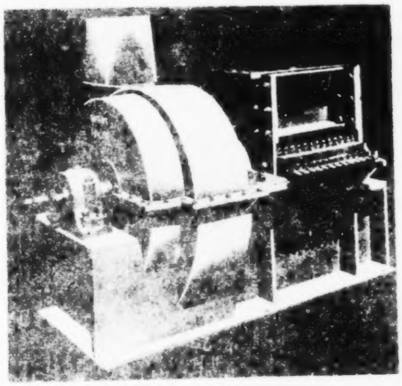
At the time it was seen at the manufacturer's plant, the equipment being used to pulp municipal wastes was in an advanced state of design and demonstration, but had not then reached the point of development where definite figures concerning capacities, water requirements and other data were available. An installation for the handling of municipal wastes has since been placed in operation in Franklin, Ohio. A commercial installation is expected to go into operation at Portland, Oregon, some time in June 1971. Based upon the manufacturer's present data, he estimates that pulpers having capacities varying from 1,000 to 4,000 pounds per hour are feasible. He estimates that maximum water requirements for the 1,000 pound per hour capacity pulper might reach a maximum of 500 gallons per hour. However, reuse of water through dewatering devices minimizes actual consumption of water. The costs of installation will vary widely but are estimated to range between $25,000 and $60,000 for the 1,000 to 4,000 pound per hour installations.

Pulping, as a method of processing solid wastes for ultimate disposal, has much merit. A distinct advantage to pulping is the ease with which the wastes can be transported as slurry in pipelines.

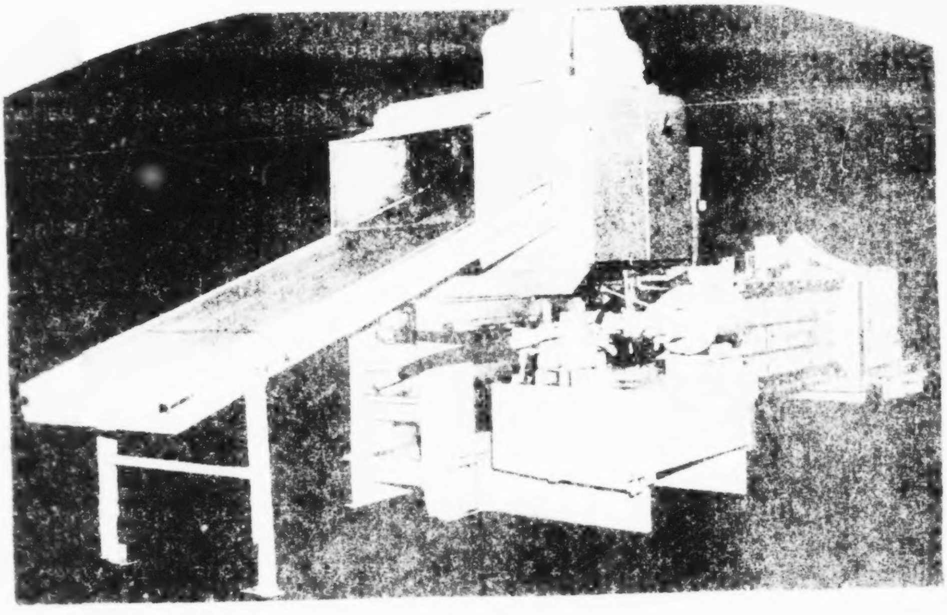
Pulverizer, Paper: This is a special purpose pulverizer, which, it is claimed, will pulverize all types of paper, including IBM cards, photographs, medical, and personal records and even offset plates and glass slides. The end product appears similar to coarse cotton. The complete system includes a cyclone separator, dust collector, and a small compactor. The actual reduction device is a swing hammer impact mill with a built-in pregrinding shredder. Models with capacities ranging from 300 to 10,000 lbs per hour are available. Pacific Paper Company, Inc., the manufacturer of a pulverizer of this type, states that a complete system for the pulverizing and compacting of the processed paper would run about $8,700 for a 400 pound per hour installation. An installation with a capacity of 1,000 pounds per hour would be about $16,400.

Shredder: Shredders are mills which are frequently used to reduce non-friable materials and are quite similar in principle to hammermills, grinders, and crushers, although the shape of hammers or knives may be different from some other mills. Hammer shapes may be of the heavy "slugger" style or of the "hog" style. Others may be variations of ring hammers, with star shapes or roughly serrated edges.

Shredders are of two main types. The down running shredder has material fed to it on the down swing of the hammers. The over running



SHREDDER AND FAN



SHREDDER AND BALER

type receives material at the top of the mill and on the upswing of the hammers. Over running, sometimes called uprunning, shredders, or crushers, are used with less friable materials, when a longer cycle in the mill is desired. Generally speaking, the size of grate openings and the arrangement and pattern of breaker plates will regulate the sizes of the finished products.

Manufacturers' catalogs give little that is specific about the capacities of shredders. This is understandable when the wide variety of uses to which the equipment might be put is considered. However, one manufacturer alone lists about thirty sizes each for down and over running shredders. Weights of the equipment run from 7,500 to 170,000 lbs in a wide range of capacities to suit almost any requirement.

Prices of shredders vary from a few thousand dollars to over $100,000 depending upon sizes, the nature of the materials to be shredded and many other factors. One shredder, or grinder, having a capacity of "up to five tons per hour, based on packer truck refuse" sells for about $20,000.

On-Site System's Effect on Final Processing and Disposal Methods

Accepted methods of final processing and disposal now prevailing in solid waste management are limited to reclamation, sanitary landfill, and incineration. It is likely in the foreseeable future that methods such as composting, pyrolysis, and other processes will be in prominent use.

Aside from the improved methods of disposal, open dumping and burning of solid wastes is one of the most commonly practiced methods.

Although this study is not directly concerned with ultimate disposal methods employed in the community, it is concerned with the effect and compatibility of on-site processing with local disposal practices. Discussions herein will be limited to these aspects.

Conditions of solid wastes, subsequent to removal for off-site disposal, are broadly classified as follows:

Uncompacted, loose, or bagged wastes
Compacted or baled wastes
Dry, shredded wastes
Wet, pulped, and dewatered wastes
Incineration residue

The general suitability of each kind of processed material can be related (Table 2) to the respective disposal methods previously mentioned; however, some qualifications are necessary.

It will be noted that open dumping and burning of wastes have been listed. Although not acceptable by today's standards, it is reemphasized that these methods are practiced in many communities. It must also be reemphasized that the purpose of this discussion is not the evaluation of acceptable disposal methods but that of the compatibility of the processed waste material with all types of disposal practiced.

Whether the physical conditions of raw waste materials are uncompacted or compacted, little effect is made upon any of the methods of disposal. This observation is based upon the effects of normal "working" of material at any disposal site. In each method of disposal, a series of activities occurs which conditions material before the final process is undertaken. Compacted material normally will be broken up into a loose state in the unloading process and/or by site or plant equipment.

Waste materials processed by shredding, pulping, or on-site incineration have received pre-conditioning with each process, offering certain advantages to various disposal systems. All these processes reduce raw wastes to a state whereby conventional scavenging is eliminated.

Shredded wastes are compatible with nearly all types of disposal, being a workable homogenous material. Decomposition will be accelerated in sanitary landfill, composting, or open dump operations. Combustion will be improved by the more uniform fuel for incineration, pyrolysis, and open burning, and the condition of the material lends itself well to mechanical separation in reclamation processes.

Dewatered pulped waste, in some respects, has similar qualities as shredded materials; however, is initially not as suitable for the combustion processes. Pulped material is more suitable for sanitary landfill and open dump operations, but can also be handled in composting and reclamation processes.

Ultimate disposal of solid waste residue after on-site incineration is limited primarily to sanitary landfill and open dumping. Reclamation of non-combustibles is also possible, although not significant except in large quantities.

In effect, regardless of the known methods of on-site processing used, the end product will not be incompatible with local disposal methods. In extreme cases where on-site compaction of wastes is accomplished using a baling system with positive ties, possible problems may arise. In such cases where disposal site equipment is not capable of breaking up baled material in normal handling operation, baling straps must be cut before deposit at the site.

TABLE 2 - SUITABILITY OF PROCESSED WASTES FOR VARIOUS DISPOSAL METHODS

Final Processing and Method of Disposal	Condition of Waste Material				
	Uncompacted	Compacted	Shredded	Pulped	Incinerated
Reclamation	0	0	+	0	0
Sanitary Landfill	0	0	+	+	+
Incineration	0	0	+	-	NA
Composting	0	0	+	0	NA
Pyrolysis	0	0	+	-	NA
Open Dumping	0	0	+	+	+
Open Burning	0	0	+	-	NA

Notes:

+ more suitable
0 suitable
- less suitable
NA not applicable

Summary

The preceding review of equipment has been carried out to identify and describe the various types of devices and mechanical components that may be considered in structuring on-site solid waste systems.

Generally, the total system concept has not yet been developed and marketed that will provide solutions to all of the many different problems of processing, storage, and handling of solid wastes in building complex systems. However, substantial progress is being made in the development of individual components.

Various types of processing equipment (such as compactors, balers, grinders, pulpers, incinerators, etc.), all offering a wide range of capacities, have been developed for solid waste systems in buildings. Reduced storage space requirements can be accomplished with the use of such waste reduction devices, and building sanitation and safety can also be improved. Lesser progress is evident in on-site transport systems exclusively for solid wastes. In addition to the practical and economical gravity chute, available methods are limited to prototype pneumatic conveyors and slurry pipelines. Where such methods can be adapted, interim storage points in building complexes can be further minimized. It is the goal of this study to identify the solid waste problems in residential complexes, evaluate suitable equipment and methods, and seek alternative solutions to these problems through identification and evaluation of available systems.

IDENTIFICATION AND EVALUATION OF SOLID WASTE SYSTEMS

Identification of Basic Systems

In the investigation of solid waste systems suitable for residential complexes, nine basic functional variations were found (Table 3). These variations are generally concerned with methods of transport, processing, and storage within each of the sub-systems (Dwelling Unit, Inter-Unit, and Inter-Building). These functional variations, in most cases, only suggest broad classifications of hardware that may be used and do not identify specific selections of equipment components. These systems also vary in the types of dwelling units to which they are adaptable and the types of waste materials to be handled.

The intent of this broad classification of solid waste systems is to provide basic guidelines for selection of candidate systems for residential complexes during planning stages. Once basic systems are narrowed down for a given project, then variations of such systems can be developed employing specific selection of equipment that appears applicable to actual conditions of the project.

System Capabilities

Further investigation involved evaluation of pertinent characteristics of the sub-system components of each basic system

(Table 4). The characteristics are generally concerned with various aspects of environmental quality, performance, adaptability, compatibility, and certain economic aspects of the systems. This rating involved a judgement of the capability of each component and sub-system to meet applicable criteria and is not a direct comparison between systems.

First of all, it must be stated and re-emphasized that this overall study is not a literature review, that little, if any, statistics have been recorded on the operating characteristics or capabilities of "in-plant" solid waste systems, or, for that matter, even identification and functioning of such total systems. Consequently, evaluations of total systems herein, to a large extent, are based upon related observations and experience, a little pioneering and the application of a common sense approach in the assessment of system components, related characteristics and capabilities of these components and the intra-system effect of each component and sub-system.

The ratings, as shown in Table 4, and the deficiency ratings, shown later in Table 5, provide a means of evaluating the ability of the various system components to provide the recommended level of

TABLE 3

BASIC SOLID WASTE SYSTEMS FOR RESIDENTIAL COMPLEXES

System No.	Materials Handled			Dwelling Types Recommended					SUB-SYSTEMS										
									Dwelling Unit (DU)			Inter-Unit (IU)				Inter-Building (IB)		
									Preparation	Processing	Storage	Transport		Processing	Storage	Transport	Processing	Storage
	Garbage	Rubbish	Trash	LR/SFD	LR/SFA	LR/MF	MR/MF	HR/MF				Hor.	Vert.					
1	X			X	X	X	X	X	Segregate	Garbage Grinder	NR	Waste Line	Waste Line	NR	NR	Sewer Line	NR	NR
2	X	X	X	X	X	X			NR	NR	Lined Container	Manual or Vehicle	Manual	NR	NR or Bin	Vehicle	NR	NR or Bin
3	X	X	X		X	X			NR	NR	Lined Container	Manual	Manual	Console Compactor	Bag or Bale	Vehicle	NR	NR or Storage area
4	X	X					X	X	NR	NR	Lined Container	Manual	Gravity Chute	NR or Stationary Compactor	Bag, Bale or Container	Vehicle	NR	NR or Storage area
5	X	X				X	X	X	NR	NR	Lined Container	Manual	Gravity Chute	NR	Bin or Container	Vehicle	Stationary Compactor	Container
6	X	X					X	X	NR	NR	Lined Container	Manual	Gravity Chute	NR	Base of Chute	Pneumatic Tube	Stationary Compactor or Incin.	Container
7	X	X					X	X	NR	NR	Lined Container	Manual	Gravity Chute	Dry Grinding or Shredding	NR or Container	Pneumatic Tube	NR or Comp. or Incin.	Container
8	X	X					X	X	NR	NR	Lined Container	Manual	Gravity Chute	Wet Grinding or Pulping	NR	Slurry Pipeline	Dewatering	Container
9	X	X		X	X	X			NR	Under-Counter Compactor	Compactor Bag	Manual	Manual	NR	Bin or Container	Vehicle	NR	NR or Container

NR - Not Required

TABLE 4

SUMMARY OF SYSTEM CAPABILITIES

SYSTEMS CHARACTERISTICS	SYSTEM NUMBER																													
	No 1			No 2			No 3			No 4			No. 5			No 6			No 7			No 8			No 9			No		
	Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem		
	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB
1. Type of Waste																														
a. Garbage	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+	0	+	+			
b. Rubbish	NA	NA	NA	0	0	0	0	+	+	0	+	+	0	0	+	0	+	+	0	+	+	0	+	+	+	+	+			
c. Trash	NA	NA	NA	0	0	0	0	+	+	0	+	+	0	0	+	0	+	+	0	+	+	0	+	+	0	+	+			
2. State of Development	+	+	+	+	0	0	+	0	+	+	0	+	+	0	+	+	0	0	+	-	0	+	-	+	0	0	+			
3. Practicability and Operability	+	+	+	0	0	0	0	+	0	0	+	0	0	-	+	0	+	+	0	+	+	0	+	+	+	+	0			
4. Economic Characteristics																														
a. Economy of Increase Loading	+	+	+	+	0	0	+	0	0	+	+	0	+	0	0	+	+	+	+	+	+	+	+	+	+	+	0			
b. Economy throughout Expected Life	0	+	+	+	0	0	+	0	0	+	+	0	+	-	0	+	+	+	+	+	+	+	+	+	+	+	0			
5. Reliability and Durability																														
a. Demonstrated	+	+	+	0	0	0	0	0	+	0	0	+	0	0	+	0	0	0	0	-	0	0	0	+	0	+	+			
b. Predicted	NA	NA	NA	NA	NA	NA	NA	+	NA	NA	NA	NA	NA	NA	NA	NA	NA	+	NA	+	+	NA	+	NA	+	NA	NA			
6. Maintainability	+	+	+	0	0	0	0	0	+	0	0	+	0	-	+	0	0	0	0	0	0	0	0	+	+	+	+			
7. Adaptability of Integration with,																														
a. Other utility systems	+	+	+	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	+	NA	0	+	NA	+	+	NA	NA	NA			
b. Other maintenance services	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	NA	+	0	NA	+	0	+	0			
8. Adaptability to Site Requirements	+	+	+	0	0	0	0	+	0	0	+	0	0	0	0	0	+	0	0	+	0	0	+	0	0	+	0			
9. Adaptability for Disposal to,																														
a. Sanitary landfill	NA	NA	NA	0	+	+	0	+	+	0	+	+	0	+	+	0	+	+	0	+	+	0	+	+	0	+	+			
b. Incineration	NA	NA	NA	0	+	+	0	+	+	0	+	+	0	+	+	0	+	+	0	+	+	0	-	-	0	+	+			
c. Recovery of resources	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
10. Environmental Quality																														
a. Sanitation	+	+	+	0	0	0	0	+	+	0	0	+	0	-	0	0	0	+	0	0	+	0	0	+	+	+	+			
b. Noise	0	+	+	0	-	-	0	+	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	0	+	+	0			
c. Air pollution	+	+	+	0	0	0	0	+	+	0	0	+	0	-	0	0	0	+	0	0	+	0	0	+	+	+	+			
d. Esthetics	+	+	-	-	-	-	-	+	0	-	0	0	-	-	0	-	0	+	-	+	+	-	+	+	+	0	0			
11. Safety																														
a. Fire and explosions	+	+	+	0	0	0	0	+	+	0	0	+	0	-	0	0	0	+	0	-	+	0	+	+	+	+	+			
b. Public and operator	+	+	+	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	+	0	0	0			
12. Operation Constraints	0	+	+	0	0	0	0	+	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	+	0	+	0			
13. Adaptability to,																														
a. Increased loading	+	+	+	0	0	0	0	+	+	0	+	+	0	-	+	0	+	+	0	+	+	0	+	+	0	+	+			
b. Variation in waste characteristics	0	0	0	0	0	0	0	0	+	0	0	+	0	0	+	0	0	+	0	0	+	0	0	0	0	+	+			
14. Availability for Meeting Construction Schedules	+	+	+	NA	NA	NA	NA	+	+	NA	+	+	NA	+	+	NA	+	+	NA	0	+	+	0	+	+	NA	NA			
15. Compatibility with Housing Types																														
a. LR/SFD	+	+	+	+	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	+	0	0			
b. LR/SFA	+	+	+	0	0	0	0	+	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	+	0	0			
c. LR/MF	+	+	+	0	0	0	0	+	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	+	0	0			
d. MR/MF	+	+	+	NA	NA	NA	NA	NA	NA	0	+	0	0	-	+	0	+	+	0	+	+	0	+	+	NA	NA	NA			
e. HR/MF	+	+	+	NA	NA	NA	NA	NA	NA	0	+	0	0	-	+	0	+	+	0	+	+	0	+	+	NA	NA	NA			

NOTES:

+	More suitable	DU =	Dwelling Unit
0	Suitable	IU =	Inter-Unit
-	Less suitable	IB =	Inter-Building
		NA =	Not Applicable

TABLE 5

SUMMARY OF SYSTEM EVALUATION

	SYSTEMS CHARACTERISTICS	SYSTEM NUMBER																																
		No 1			No. 2a			No. 2b			No. 2c			No. 3			No. 4			No. 5			No. 6			No. 7			No. 8			No. 9		
		Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem			Subsystem		
		DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB	DU	IU	IB
1.	Type of Waste																																	
	a. Garbage	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	3	3	2	3	3	2	3	3	1	2	2	2
	b. Rubbish	NA	NA	NA	2	2	2	2	2	2	2	2	2	2	1	1	2	1	2	2	3	2	2	1	1	2	1	1	2	1	1	0	1	1
	c. Trash	NA	NA	NA	2	2	2	2	2	2	2	2	2	2	1	1	2	1	2	2	3	2	2	1	1	2	1	1	2	1	1	1	1	1
2.	State of Development	1	0	0	2	1	1	2	1	1	2	1	1	2	2	0	2	1	1	2	2	1	2	1	2	2	4	2	2	4	1	2	1	1
3.	Practicability and Operability	0	0	0	2	1	1	2	1	1	2	0	1	2	1	0	2	0	1	2	3	1	2	0	1	2	1	1	2	1	1	1	1	1
4.	Economic Characteristics																																	
	a. Economy of Increase Loading	0	0	0	0	2	2	0	3	2	0	0	2	0	2	2	0	0	2	0	3	3	0	0	0	0	1	0	0	1	0	1	2	2
	b. Economy Throughout Expected Life	2	1	1	0	2	2	0	3	2	0	0	2	0	2	2	0	0	2	0	5	3	0	0	0	0	1	0	0	1	0	1	2	2
5.	Reliability and Durability																																	
	a. Demonstrated	2	1	1	1	2	2	1	2	2	1	1	2	1	2	2	1	2	2	1	3	2	1	2	2	1	3	2	1	3	1	1	2	2
	b. Predicted	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	NA	2	0	NA	1	NA	0	NA	NA
6.	Maintainability	1	0	0	2	2	2	2	2	2	2	1	2	2	1	1	2	2	2	2	4	2	2	2	2	2	3	2	2	3	1	1	2	2
7.	Adaptability of Integration with,																																	
	a. Other utility systems	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	0	NA	1	0	NA	NA	NA
	b. Other maintenance services	NA	NA	NA	2	2	2	2	1	2	2	1	2	2	1	1	2	1	2	2	2	2	2	2	0	2	2	0	2	NA	0	1	1	2
8.	Adaptability to Site Requirements	0	0	0	2	3	3	2	2	2	2	1	1	2	0	1	2	0	1	2	3	3	2	0	2	2	1	2	2	1	2	1	2	1
9.	Adaptability for Disposal to,																																	
	a. Sanitary landfill	NA	NA	NA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	1	1	1
	b. Incineration	NA	NA	NA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	1	1	1
	c. Recovery of resources	NA	NA	NA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	0	0	1	0	0	1	1	1
10.	Environmental Quality																																	
	a. Sanitation	1	0	0	2	2	2	2	2	2	2	2	1	2	1	1	2	1	1	2	4	3	2	1	0	2	2	0	2	2	1	0	1	1
	b. Noise	1	0	0	2	3	3	2	2	3	2	2	2	2	1	1	2	1	2	2	3	3	2	1	2	2	3	2	2	3	2	0	1	1
	c. Air pollution	2	0	0	2	2	2	2	2	2	2	2	1	2	1	1	2	2	1	2	4	3	2	2	1	2	3	1	2	3	0	0	1	1
	d. Esthetics	2	0	0	3	3	3	3	3	3	3	3	2	3	1	2	3	1	2	3	4	3	3	1	0	3	2	0	3	1	0	0	2	1
11.	Safety																																	
	a. Fire and explosions	0	0	0	2	2	2	2	2	2	2	3	1	2	1	1	2	2	1	2	4	2	2	2	1	2	4	1	2	1	0	0	1	1
	b. Public and operator	0	0	0	2	3	3	2	2	3	2	2	2	2	2	3	2	1	2	2	4	3	2	1	2	2	3	2	2	3	1	1	1	2
12.	Operation Constraints	0	0	0	2	1	1	2	1	1	2	1	1	2	0	1	2	1	1	2	4	2	2	1	2	2	2	2	2	3	1	1	1	1
13.	Adaptability to,																																	
	a. Increased loading	0	0	0	2	2	2	2	1	2	2	1	2	2	1	1	2	0	2	2	4	2	2	0	0	2	1	0	2	1	0	1	1	2
	b. Variation in waste characteristics	0	0	0	2	2	2	2	2	2	2	1	2	2	1	2	2	2	2	2	3	2	2	2	1	2	3	1	2	3	2	1	2	2
14.	Availability for Meeting Construction Schedules	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0
15.	Compatibility with Housing Types																																	
	a. LR/SFD	0	0	0	0	0	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	NA	NA	NA	NA	0	0	0
	b. LR/SFA	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	NA	NA	NA	NA	0	0	0
	c. LR/MF	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	NA	NA	NA	NA	0	0	0
	d. MR/MF	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	NA
	e. HR/MF	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	NA
	Deficiency Rating	12	2	2	40	47	47	40	42	44	40	32	37	40	28	30	40	25	37	40	71	52	40	25	20	40	48	22	40	43	17	19	31	32

NOTES: Deficiency Grading:

0	No deficiency
1	Very good or more adequate
2	Good or adequate
3	Fair or less adequate
4	Poor or needs improvement
5	Not suitable or inadequate

service compatible with Operation Breakthrough's general planning objectives and within the limits of user habits discussed earlier.

A general discussion on types of factors considered in development of these ratings is presented on each of the System Characteristics identified in Tables 4 and 5.

Type of Waste Handled: Rating the capability to handle the various types of wastes within the limitations of the systems' design is based substantially on the efficiency of the initial preparation or processing of wastes performed in the DU and the subsequent effect such handling will have in the IU and IB sub-systems. This basis is further explained by the following discussion of all DU sub-systems.

System 1 - In-sink grinder is capable of handling garbage only, but efficiently at the source without rehandling. Assumes that users do not include small children.

Systems 2 through 8 - All employ deposit of wastes in lined containers. Waste materials must then be transported daily at frequent intervals to outside lined container for DU storage or provided inside storage for daily accumulations in lined containers for subsequent transport to IU storage or processing. These systems are capable of handling all types of wastes but assumes capability of handling wet garbage wastes without frequent mishaps is unlikely.

Assumes DU users of all ages including small children as frequent users.

System 9 - Under-counter compactor capable of handling all types of wastes in DU, and adjacent to, or at source of, generation minimizing handling. Also capable of inside protected storage of relatively large quantities of wastes and minimizes frequency of transport outside of DU and opportunities of subsequent mishap en route. Assumes operation of unit and handling of compacted bagged wastes will not be performed by small children.

State of Development: Considers factors such as historic use of common components or principals of mechanics and operation of newer components. Also, probability of improvement in functioning or quality of components.

Practicability and Operability: Considers factors of simplicity of use, user acceptance and/or adequacy for intended purpose together with the resulting level of service.

Economic Characteristics: Assumes that economic justification of the system has been established and reconciled with the level of service desired for initial operating conditions. However, the following factors concerned with future loadings and use are also pertinent.

a. Economy of increased loading: Considers such factors as required addition of components, labor, repairs, and supplies, system modifications or abandonment of system.

b. Economy throughout expected life: Considers the capability of components to handle future loadings at reasonable increase in costs together with a reasonable life expectancy of system components.

Reliability and Durability: Considers demonstrated capabilities of system components to handle various types of waste materials to which they are subjected. Mechanical principles, quality and use tests are also considered for those newer components on the market. The latter factors, together with present technology, are the principal bases for predicted improvements in these components.

Maintainability: Considers demonstrated or predicted efficiency in maintenance (mechanical and housekeeping) and costs of maintenance related to the resulting quality of service.

Adaptability of Integration with Utility Systems and Other Maintenance Services: Considers characteristics of labor, equipment, and maintenance required for system operation and the compatibility of such characteristics with other similar in-plant requirements.

Adaptability to Site Requirements: Considers the design, installation, and operating characteristics of systems versus the requirements of design, construction and occupancy stages of the types of housing projects with which the systems are compatible.

Adaptability to Disposal by Sanitary Landfill, Incineration or Recovery of Resources: Considers the ultimate effect of the individual components on the methods of final processing or disposal.

Environmental Quality: Considers the effect of the individual components on controlling environmental quality (sanitation, noise, air pollution and esthetics) and considers that preceding methods (components) used in the system may have subsequent effect throughout the system. In the case of noise ratings, location, frequency, and duration of use and associated actions in connection with use are considered as well as the level of such noise.

Safety: Considers susceptibility of components to fire and explosion under normal operating conditions. Also considers hazards to users and general public under such conditions. Protective devices available on mechanical components are of major concern, as are the unprotected non-mechanical components or methods employed in the system.

Operation Constraints: Considers limitations in use of the components and the progressive effect throughout the system. Types of waste handled, conditioning of materials for subsequent handling, efficiency of handling, simplicity of operation by user and/or operator are types of factors considered.

Adaptability to Increased Loadings and Variations of Waste Handled: Considers required modifications, additional supplies, labor, and maintenance for components and system operation under increased loadings and the efficiency in handling the various types of wastes.

Availability for Meeting Construction Schedules: Assumes that consideration and selection of the waste system will be made during planning stages and that scheduling, procurement, and installation of "built-in" components will receive normal attention during construction. The size or complexity of the system alone are not considered to govern this rating. Other factors such as normal availability of construction materials, standard mechanical components, and special fabrications required for the system installation, and the ability to merge the installation in the overall construction schedule are of major significance.

Sub-systems which are composed of accessory items, such as vehicular transport, cans, and containers, not affecting construction are classified as "not applicable."

Compatibility with Housing Types: Considers the types of complexes to which the systems are primarily compatible. For example, the pneumatic collection system (System 6) is primarily intended for considered use in high density (MR/MF and HR/MF) complexes, the console compactor (System 3) is intended for grouped low-rise housing while the under-counter compactor (System 9) is intended for all types of low-rise units.

Summary: To further elaborate on this method of evaluation, a brief analysis of the rating of System No. 1 is presented. This system, employing the garbage grinder in the Dwelling Unit (DU) Sub-system, received a relatively high ranking. Although the garbage grinder only handles a single type of waste, it does it efficiently, as reflected in the DU rating. The pipeline handling of the processed wastes is also rated with high efficiency in the Inter-Unit (IU) and Inter-Building (IB) Sub-systems. The rating basically suggests that this proven system provides a high level of service, within reasonable economic limits, and that it is adaptable to all types of housing. The rating further implies that the loading capacity of the unit is not a critical factor and that standard components are readily available so as not to unduly affect construction.

This rating in Table 4 does not intend to make a direct comparison between systems, although, unavoidably, certain conclusions can be drawn.

Certain repetition in ratings have been made in cases where similar or identical methods are used in the different systems. For example, the DU Sub-system in Systems No. 2 through 8 are similar and the transport component in the IU Sub-system of Systems No. 4 through 8 are identical.

Economic Factors

Basic economic evaluation of systems should consider the initial capital investment and annual operating cost that may be incurred by the developer, which, in turn, is passed on to the resident (owner or renter), as well as the continuing costs that may be incurred only by the resident.

In a residential complex where site configuration is such that all residences may be served by conventional municipal services, capital investments for special system facilities may be totally eliminated, and the resident may directly incur all costs.

Typical direct charges per single family residence for conventional municipal collection and disposal services generally range between $24 and $36 annually. Such charges vary with the area and type of service available. In many instances the direct charges assessed to the residence do not include all costs of municipal services and overcosts are funded from tax revenues. In many cities the total costs of municipal solid waste services are funded from tax revenues. The trend is for increasing costs in municipal solid waste services which is highly influenced by escalating labor rates. In addition to these costs, the recipient of this service incurs the cost of storage containers, liners, and other required accessories. Assuming the average dwelling unit will require an average of 3-30 gallon liners per week at a cost of about $0.07 each, costs of liners alone will be about $11 annually. Together with the cost of containers and sanitizing, it is estimated that to provide a recommended level of service, costs of total accessories will likely range from $12 to $18 per year.

Should the developer or resident elect to install accessory processing devices for wastes such as garbage grinders or under-counter compactors, substantial capital investment is required, as well as continuing costs.

The conventional kitchen garbage grinder of reasonable quality will range between $75 to $150 installed. With a life expectancy of about ten years, this unit will likely cost the user between $15 and $25 annually, including capital expense (amortization of installed cost), maintenance, repairs, and operating costs. The above estimate is based on the following allowances:

Purchase price range	$50	$125
Installation, handling, and electrical service	25	25
Installed cost	$75	$150

Equivalent annual cost:

Amortization (10 yrs @ 6 percent - Rate 0.1360)	$10.20	$19.40
Maintenance, repairs, and operating costs	5.00	5.00
Estimated average annual cost	$15.20	$24.40

The under-counter compactor, currently being marketed at discounted prices as low as $170 in quantities and a retail cost of about $230 with an assumed life expectancy of about ten years, will likely cost the user about $60 to $67.50 annually, including capital expense (amortization of installed cost), maintenance, repairs, and supplies. The above estimate is based on the following allowances:

Purchase price range	$170	$230
Installation, handling, and electrical service	20	20
Installed cost	$190	$250
Equivalent annual cost:		
Amortization (10 yrs @ 6 percent - Rate 0.1360)	$25.84	$34.00
Maintenance, repairs, and operating costs	8.50	8.50
Supplies (bags and sanitizing spray)	25.00	25.00
Estimated average annual cost	$59.34	$67.50

The installation of devices, such as kitchen grinders and compactors, provides advantages to the collection agencies by elimination or volume reduction of materials handled and possible reduction in frequency of collection required. The residents' benefits are limited to the convenience and improved environmental standards at increased cost. This comparison illustrates that to achieve improved standards of system operation in the single family dwelling unit, a substantial increase in total annual costs will be incurred.

In large residential complexes of mixed dwelling unit types, several of the basic systems may be required and may require contract or management collection services. In such complexes, possible economies in collection may be passed on to the residents to partially defray increase costs. This factor may become more significant considering the increasing cost of collection labor and long-range economies that may likely result.

Summary of Systems Evaluations

Variations of the conventional collection system (System No. 2) as shown in Table 5 are identified as follows:

System 2a - The conventional municipal collection, consisting of house-to-house collection with a conventional mobile packer.

System 2b - House-to-house collection using either a satellite collection vehicle or multi-purpose maintenance vehicle for transfer of collected waste materials to intermediate storage locations.

System 2c - Occupants are required to deposit accumulated waste in bins, centrally located in clusters. Multi-purpose maintenance vehicles will tow these bins to intermediate storage locations.

Evaluation of the previously identified systems involved a comparison of system characteristics. The comparison is illustrated by a simplified deficiency rating of characteristics of the sub-systems of each system (Table 5). The determination of deficiency values of systems' characteristics was based on similar factors considered in the rating of system capabilities (Table 4). This deficiency value rating method was resolved to a six step grading proces (0 to 5) of each characteristic in each sub-system and collectively represent a deficiency rating of the total system.

This comparison indicates advantages that may be expected by processing in the dwelling units and subsequent transport of waste materials in a closed system. The advantages of such a combination are illustrated by the low deficiency rating in the case of System 1, which utilizes grinders with sewer line transport of the processed materials.

System 9, employing under-counter compactors for improved storage of wastes in the dwelling unit and conditioning for subsequent transport, also reflects a relatively low deficiency rating.

Systems 2 through 8 employ the same or similar conventional methods in the dwelling unit sub-system and consequently have identical ratings.

System 6, employing pneumatic pipeline conveyance of waste materials would provide a desirable level of service in the Inter-Unit and Inter-Building sub-systems.

Variations in the deficiency ratings of the other systems shown are affected by differing methods in the Inter-Unit and Inter-Building sub-systems only.

Development of devices for processing of waste materials in the dwelling unit and/or devices for direct admission of waste materials from the dwelling unit into a pneumatic pipeline system, coupled with the Inter-Unit and Inter-Building pneumatic conveyor system, would likely provide an optimum system for handling of all types of domestic wastes. Such a system would be comparable to the deficiency rating of System 1, which is limited to the handling of garbage.

Site Factors

The earlier discussion of general requirements of solid waste systems provides basic guidelines that must be considered for any residential complex in the planning stage. In addition, specific project conditions that would influence solid waste management must be considered for individual projects. These include the physical characteristics of the site (size, shape or proportions, topography, and soils), site planning, local regulations, and solid waste management practices. Other factors such as characteristics of the surrounding community, environmental quality requirements, and area climatic conditions must also be considered in the selection of candidate systems.

The following sections of this division of the report present general descriptive details of the site analysis made on each of the Operation Breakthrough projects, together with the planning analyses of solid waste systems for each, based upon data available on proposed site conditions at the time of this study.

SELECTION OF SYSTEMS FOR OPERATION BREAKTHROUGH PROJECTS

This division of study is concerned with the investigation of each of the nine housing developments in the Operation Breakthrough program. This investigation, conducted during the conceptual design stages of these projects, has included a review of initial planning studies, available interim reports and site plans, as well as conferences with Site Planners, in efforts to obtain adequate data for identification of the solid waste system requirements of each project.

The location and respective number of dwelling units proposed in these housing developments are listed as follows:

1.	Macon, Georgia	305
2.	Memphis, Tennessee	476
3.	St. Louis Missouri	463
4.	Indianapolis, Indiana	300
5.	Kalamazoo, Michigan	220
6.	Jersey City, New Jersey	500
7.	Sacramento, California	407
8.	Seattle, Washington	60
9.	King County, Washington	162

Within this group of projects, a wide variety of dwelling unit types and sizes will be found, as well as a wide variety of building types and site configurations. A summary of project descriptions (Table 6) indicates such characteristics as housing mix, size mix, average DU density, resident population, and size and type of ancillary facilities of each complex. Certain of these projects will contain extensive community facilities such as schools, commercial establishments, and offices, in addition to recreational and social centers generally common to all. All of the functions in the respective projects must be accommodated by a combination of components of the solid waste systems considered. Specific characteristics of waste system requirements are identified in the individual project studies.

Initial selection of candidate systems (Table 7) for the Operation Breakthrough projects can be based on the types of dwelling unit structures proposed in each project. However, refinement of this selection and evaluation of systems require that individual analyses be made for each project and the actual selection of systems may be either further limited or expanded.

The preliminary cost estimates of the various systems considered for these projects are based on reasonable allowances for maintenance, repair, and labor, as well as purchase of equipment and supplies. To

TABLE 6

SUMMARY OF PROJECT DESCRIPTIONS

Proj. No.	Location	CHARACTERISTICS OF DWELLINGS Type (1) (2) (3)	Size Eff.	1BR	2BR	3BR	4BR	5BR	Total # of DU	Total Land Acres	Density DU A	Avg. DU Popul.	Est. Resident Popul.	ANCILLARY FACILITIES (Building Area - Square Feet) Comm. Center	Adm & Maint.	Other Facil.	Total Area
1	Macon	LR SFD LD	-	-	-	8	12	-	20								
		LR SFA LD	-	-	45	99	26	-	170								
		LR MF MD	-	12	20	4	-	-	36								
		MR MF HD	-	-	18	6	-	-	24								
		HR MF HD	-	33	22	-	-	-	55								
		(TOTAL)	-	45	105	117	38	-	305	50	6	4.1	1,256	4,250	1,150	300	5,700
2	Memphis	LR SFA MD	-	-	18	58	6	-	82								
		LR MF MD	-	-	72	30	-	-	102								
		LR MF HD	100	100	92	-	-	-	292								
		(TOTAL)	100	100	182	88	6	-	476	12	40	3.2	1,528	NA	NA	NA	NA
3	St. Louis East Site	LR MF HD	17	7	65	41	-	-	130								
		MR MF HD	9	-	18	-	-	-	27								
		MR MF HD	20	40	20	4	-	-	84								
		(TOTAL)	46	47	103	45	-	-	241	7.6	31	3.0	720	NA	NA	NA	11,000
	West Site	LR SFA MD	-	-	10	25	40	-	75								
		LR MF MD	-	10	40	-	-	-	50								
		MR MF HD	-	-	25	-	-	-	25								
		HR MF HD	18	43	11	-	-	-	72								
		(TOTAL)	18	53	86	25	40	-	222	8	28	3.6	805	NA	NA	NA	8,700
4	Indianapolis	LR SFD LD	-	-	13	50	50	-	113								
		LR SFA MD	-	-	42	40	-	-	82								
	*LR & MR	* MF HD	-	50	55	-	-	-	105								
		(TOTAL)	-	50	110	90	50	-	300	52	6	4.1	1,230	3,000	NA	5,000	8,000
5	Kalamazoo	LR SFD LD	-	-	-	15	3	-	18								
		LR SFA MD	-	-	71	29	7	1	108								
		LR MF HD	3	50	33	8	-	-	94								
		(TOTAL)	3	50	104	52	10	1	220	35	6.3	3.4	756	2,000	NA	7,000	9,000
6	Jersey City	LR MF MD							NA								
		MR MF HD							NA								
		HR MF HD							NA								
		(TOTAL)	25	155	190	100	30	-	500	6.5	77	3.3	1,640	3,000	NA	65,000	68,000
7	Sacramento	LR SFD LD	-	-	-	9	11	-	20								
		LR SFA LD	-	-	24	97	60	-	181								
		LR MF MD	-	38	50	8	-	-	96								
		HR MF HD	-	110	-	-	-	-	110								
		(TOTAL)		148	74	114	71	-	407	32	12.7	3.9	1,555	13,000	1,000	4,000	18,000
8	Seattle	LR MF HD	-	-	-	23	11	3	37								
		MR MF HD	-	-	23	-	-	-	23								
		(TOTAL)	-	-	23	23	11	3	60	1.7	35	4.8	235	1,600	NA	4,500	6,100
9	King Co.	LR SFD LD	-	-	-	10	30	18	58								
		LR SFA LD	-	-	20	40	20	-	80								
		LR MF MD	-	-	12	12	-	-	24								
		TOTAL)	-	-	32	62	50	18	162	30	5.4	5.5	900	3,000	NA	2,000	5,000

Explanation of Dvelling Types (1), (2), and (3)

(1) HR - High-rise (over 7 stories)
MR - Medum-rise (4 to 7 stories)
LR - Low-rise (under 4 stories)

(2) MF - Multifamily
SFA - Single Family Attached
SFD - Single Family Detached

(3) HD - High Density (over 20 DU A)
MD - Medium Density (11 to 20 DU/A)
LD - Low Density (1 to 10 DU/A)

avoid repetition in descriptions and calculations of these preliminary estimates and their components certain qualifications are made herein.

Capital investment or costs as identified for each system include allowance for initial purchase and cost of installation where applicable. Equivalent annual capital costs cover amortization of the total capital investment (average annual principal and interest) over the expected life of the equipment installation. In all cases an interest rate of 6 percent per annum has been allowed. The following amortization rates have been used in calculation of equivalent annual capital costs:

Expected Life Term	Annual Amortization Rate
5 Years	23.75%
10 Years	13.60%
50 Years	6.35%

Labor allowances of $3.50 per hour for semi-skilled maintenance personnel have been used at all locations. These allowances are intended to include all payroll taxes, insurance, and fringe benefits. No escalation factor is allowed for labor costs over the life term of the installation. Adjustments to the preliminary cost estimates would be required for these variables when factual data is available for each project.

TABLE 7

INITIAL SELECTION OF BASIC CANDIDATE SYSTEMS

Project		Dwelling Units		Basic Candidate Systems								
No.	Location	Type	No.	1	2	3	4	5	6	7	8	9
1	Macon Georgia	LR SFD	20	X	X							X
		LR SFA	170	X	X	X						X
		LR MF	36	X	X	X						X
		MR MF	24	X			X					
		HR MF	55	X			X					
		TOTAL	305									
2	Memphis Tennessee	LR SFA	82	X	X	X		X	X			X
		LR MF	102	X	X	X		X	X			X
		HR MF	292	X			X	X	X			
		TOTAL	476									
3	St. Louis, Missouri East Site	LR MF	130	X	X	X		X				X
		MR MF	27	X			X	X				
		HR MF	84	X			X	X				
		TOTAL	241									
	West Site	LR SFA	75	X	X	X						X
		LR MF	50	X	X	X		X				X
		MR MF	25	X			X	X				
		HR MF	72	X			X	X				
		TOTAL	222									
4	Indianapolis Indiana	LR SFD	113	X	X							X
		LR SFA	82	X	X	X						X
		LR-MR MF	105	X	X	X						
		TOTAL	300									
5	Kalamazoo Michigan	LR SFD	18	X	X							X
		LR SFA	108	X	X	X						X
		LR MF	94	X	X	X						X
		TOTAL	220									
6	Jersey City New Jersey	LR MF	NA	X		X		X	X			
		MR MF	NA	X			X	X	X			
		HR MF	NA	X			X	X	X			
		TOTAL	500									
7	Sacramento California	LR SFD	20	X	X							X
		LR SFA	181	X	X	X						X
		LR MF	96	X	X	X						X
		HR MF	110	X			X					
		TOTAL	407									
8	Seattle Washington	LR MF	37	X	X	X						X
		MR MF	23	X		X	X					
		TOTAL	60									
9	King County Washington	LR SFD	58	X	X							X
		LR SFA	80	X	X	X						X
		LR MF	24	X	X	X						X
		TOTAL	162									

Statistical cost data on municipal and private collection and disposal services are often expressed in terms of the annual service charge per residence, cost per ton or cost per cubic yard. Wide variations in costs often exist within the community and between communities. These variations are due to many factors such as:

1. Type and frequency of collection service
2. Quantities and types of waste collected
3. Type of collection equipment used
4. Type of disposal facilities used
5. Labor requirements for collection and disposal
6. Density of collection districts
7. Haul distance to disposal facilities

Many other factors exist, but as above, nearly all are subject to change and all are cost factors. The trend is for escalation in costs of service, or reduction in the level of service in efforts to hold-the-line on costs.

Where direct annual service charges are made for residential services they are today popularly found in a range between $24 to $36 a year. These charges do not necessarily include all costs and quite often exclude capital expenses. A few cities are going to a full service charge basis and attempting to develop self-sustaining solid waste management divisions. Metropolitan Dade County, Florida, is representative of this type of system where the current rate of charge to residences is $54 annually. Metro officials presently are exploring alternatives in service to hold costs within this limit.

In this study of Operation Breakthrough projects, costs of service involved determination of direct service charges per dwelling unit where applicable and estimates of alternative cost for commercial services. In the latter case, costs are generally based on costs per ton or cubic yard. To assist in the evaluation and comparison of service costs the following tabulations are made based upon average annual dwelling unit waste production of say 2 tons or 24 cubic yards (average DU population of 3.5 persons x 3 pounds daily per capita production = 10.5 pounds per day per DU x 30 days = 315 pounds per month per DU x 12 months = 3,800 pounds per year per DU or 1.9 tons. 3,800 pounds / 6 pounds per cubic foot = 633 cubic feet / 27 = 23.44 cubic yards).

Comparison of Methods of Charge

Annual Rate Per DU	Equivalent Cost Per Ton	Equivalent Cost per C.Y.
$12	$ 6	$0.50
18	9	0.75
24	12	1.00

30	15	1.25
36	18	1.50
42	21	1.75
48	24	2.00
54	27	2.25

Basic cost components of municipal or private contractor services are the disposal, collection, and haul costs.

Extremely wide variations in disposal costs will be found by comparison of such methods as open dumping, sanitary landfill, and incineration. However, with the present emphasis on upgrading disposal methods, realistic cost factors for disposal for purposes of this evaluation should be limited to either sanitary landfill or the alternative of acceptable incineration processes. Charges to the recipient of sanitary landfill disposal services will generally range between \$0.125 to \$0.25 per cubic yard or \$1.50 to \$3.00 per ton. Charges for disposal by incineration will be at least double the cost of sanitary landfill (from \$0.25 to \$0.50 per cubic yard or \$3.00 to \$6.00 per ton).

Collection and haul costs though highly variable can be summarized by the following hypothetical example of municipal systems. A typical 20-cubic yard compactor truck with a three-man collection team has a normal capability of collecting and transporting two loads of wastes per day. Assuming a compaction ratio of three to one, this team will handle about 20,000 lbs (2 loads x 60 cu yds x 170 pounds per cubic yard) or 10 tons per day. Assuming labor costs of about $84 per day (3 men x 8 hours x $3.50 per hour) and equipment costs of $40 (8 hours at $5.00 per hour), total daily costs of about $124 result. Approximately 75 percent of daily costs may be attributed to collection and 25 percent to haul or an estimated average cost of about $8.30 per ton for collection and $4.10 for haul.

Relating the above to annual dwelling unit costs with an average waste production of two tons annually the following breakdown of the costs of service results.

Cost Range of Sanitary Landfill	$ 3.00	$ 6.00
Haul Costs	8.00	8.00
Collection Costs	17.00	17.00
Total Annual DU Costs	$28.00	$31.00

Cost Range of Incineration	$ 6.00	$12.00
Haul Costs	8.00	8.00
Collection Costs	17.00	17.00
Total Annual DU Costs	$31.00	$37.00

Costs of commercial service for bulk handling of containerized wastes may reflect savings in the order of 50 percent in collection and haul costs, but disposal costs remain generally constant. The ultimate effect of such savings on costs of the total service to a dwelling unit can be summarized as follows:

Cost Range of Sanitary Landfill	$ 3.00	$ 6.00
Collection and Haul Costs	12.50	12.50
Total Annual DU Cost	$15.50	$18.50

Cost Range of Incineration	$ 6.00	$12.00
Collection and Haul Costs	12.50	12.50
Total Annual DU Cost	$18.50	$24.50

Comprehensive solid waste management studies were not available on the communities in which Operation Breakthrough projects are located. However, information that was available on services, generally indicated that charges or costs of service for single family dwelling units are in a range of $24 to $34 annually and in some cases lower costs for multifamily units. In a few cases such costs are included in the tax burden rather than a direct charge basis. Considerable discussion was carried out during the course of this study on handling of such "hidden" costs in the cost analysis and comparison of system costs. Two methods of handling were considered: (1) hidden costs should be identified as zero costs or (2) show such unidentified costs as minimal allowances, i.e. a real cost that is also subject to future escalation and not a misleading fixed zero increment. The latter method was adopted for purposes of this study due to the present trend by cities to convert to a direct charge basis. It also appears reasonable to assume that municipalities should willingly encourage negotiations with developers of large residential complexes to improve the internal level of collection service without penalty to the developer or resident of dual payment or payment for services not received.

In the following studies actual costs of municipal service is identified in the case of direct service charges and an allowance of $24 per year per dwelling unit has been made to cover hidden costs in the tax structure for such services.

Macon, Georgia

This Operation Breakthrough development, to be situated on a 50-acre wooded parcel, will contain 305 dwelling units, including 20 single family detached, 170 single family attached, 36 low-rise multifamily, 24 medium-rise multifamily, and 55 high-rise multifamily units. The medium-rise and high-rise structures are grouped in the western portion of the site, together with the community center. The latter facility will provide approximately 5,700 square feet of building area for community recreational and social functions as well as management services. The low-rise structures are located in twelve principal clusters situated on both sides of a periphery loop road. Vehicular parking and required service is generally oriented to the inner parking court of each cluster with access from the loop road.

A natural lake and park area, centrally located within the site, will be preserved in this development. The perimeter area for housing development surrounding this natural setting generally slopes down to the lake.

Site Planners initially established the following program objectives preceding the evolution of this design:

1. The creation of an optimum living environment with a variety of housing types and densities clustered within a unifying open space system.

2. The provision of a design and scale appropriate to the climate and physical characteristics of the site, preserving the natural assets of the landscape as well as being complementary to surrounding development.
3. The establishment of a site design which will minimize site development costs per unit.
4. The provision of a circulation system which minimizes vehicular and pedestrian conflict while serving the ultimate needs of the residents with maximum efficiency and safety.
5. The establishment of a variety of housing types and densities to accommodate a broad spectrum of the population.
6. The provision of a unifying open space system which offers a variety of daily recreational activities appropriately related to housing clusters.
7. The provision of a community center facility to serve initially as a visitor's preview center and ultimately as the nucleus of social activity for the residents; the gathering place.
8. The provision of a site design responsible to the application of technological innovations in construction techniques.
9. The establishment of a resource management program at the inception of development to provide a basis for immediate and long-range protection of the natural amenities of the site.

10. The establishment of appropriate site design controls to preserve the inherent character of the varied environmental subareas of the site.

The present development schedule calls for site preparation to commence 29 October 1970 with completion ready for occupancy by 30 September 1971. The organization of a Cooperative Management is planned to administer those common services required for this project.

The initial planning study, as prepared by Reynolds, Smith, and Hill, Architects, Engineers, and Planners, Jacksonville, Florida, and site plan received 12 October 1970 are the principal bases for this study of solid waste systems for this project.

Estimated Quantities and Types of Wastes to be Handled: Based upon an estimated resident population of 1,256 and a monimal waste production factor of 4 lb per capita per day, it is expected that average daily waste production will be about 5,000 lbs. Distribution of this waste material by type and source of generation is estimated as follows:

Type of Waste	Garbage	Rubbish	Trash	Total
Daily Per Capita Production (lbs)	0.5	3.0	0.5	4.0
Total Daily Production (lbs)	628	3,768	628	4,924

Distribution of Total Daily Production:

Dwelling Units (lbs)	628	3,392	-	4,020
Ancillary Areas (lbs)	-	188	-	188
Outdoor Common Areas (lbs)	-	188	628	816

It is anticipated that about 13 lbs of wastes will be generated within the average dwelling unit (average 4.1 persons) each day and will consist of approximately 2 lbs of garbage, with a balance of about 11 lbs of mixed wastes for separate storage, collection, and disposal.

Available Municipal Services: The City of Macon provides separate collection of residential garbage and trash (garbage from the backyard and trash from the curb) with disposal by landfill. Approximately 80 percent of commercial wastes also are collected by the municipal agency with the balance handled by private haulers.

Regulations of storage, collection, and disposal of waste materials are presently enforced by the operational authority. Storage requirements for residence restrict container size to 30 gallons. Onsite burning of wastes other than construction, demolition, and land clearing materials is not generally practiced.

Costs of service are provided from the General Fund and are not directly charged to the residents at the present time. However, the city is expected to impose in the near future a monthly service charge of $2 per residence. This direct charge basis is considered herein.

Selection of Candidate Solid Waste Systems: The physical characteristics of this proposed development and the program objectives as outlined previously are considered herein as guidelines for selection of candidate systems. To stay within the framework of the program objectives, alternative basic systems (as identified previously) for the various types of dwelling units are limited to the following:

20 Low-rise single family detached	Systems No. 1, 2, and 9
170 Low-rise single family attached	Systems No. 1, 2, 3, and 9
36 Low-rise multifamily	Systems No. 1, 2, 3, and 9
24 Medium-rise multifamily	Systems No. 1 and 4
55 High-rise mulifamily	Systems No. 1 and 4

System No. 1 (garbage grinders) is desirable for installation in all dwelling units. Allowing an installed unit cost of $125, a total capital investment of about $38,125 will be required for the 305 dwelling units in this project. With a life expectancy of ten years and including capital expense, maintenance, repairs, and operating costs, a total annual cost of about $22 is expected to be incurred by the occupants of each dwelling unit.

System No. 2 (variations of conventional collection system) may be considered for all (226) low-rise dwelling units. These variations are identified as follows:

System 2a--The conventional municipal collection, consisting of house-to-house collection with a conventional packer truck, although in minor conflict with program objectives, is considered for economic comparison. This system, requiring no capital investment on the part of the developer, will cost the dwelling unit owner or occupant about $24 annually for service and an additional cost of about $12 annually for containers and accessories (liners, cleaning and disinfectant supplies).

System 2b--House-to-house collection service (management furnished) twice weekly, using either a satellite collection vehicle or multipurpose maintenance vehicle for transfer of collected waste materials to intermediate storage locations may be considered as an alternate to the above. Weekly production of wastes in these dwelling units and outdoor areas likely to be served by this system is estimated at about 23,350 pounds (11.6 tons or 140 cubic yards). Assuming this system will be operated on a five-day basis, an average of 4,670 pounds (2.34 tons or 28 cubic yards) will be collected daily. An average of 110 dwelling units will be served daily plus the required outdoor stations. It is estimated that intermediate storage requirements for the weekly production (with twice weekly collection from the storage areas) could be accomplished with eight intermediate stations, each providing about a nine cubic yard storage capacity. These stations can be located centrally along the collection route to minimize hauling time. It is estimated that this service could be accomplished by a properly equipped operator-collector in an average period of four hours per day.

It is estimated that capital investments for this system will be about $5,100 (based on an allowance of 50 percent for vehicle cost of $3,000 and intermediate storage stations at about $450 each). Considering a five-year life expectancy on such equipment, an equivalent annual capital cost (amortization of principal and interest) of about $1,180 can be expected. In addition to the above cost, an estimated expense of $1,500 annually will be incurred in vehicular equipment operation, maintenance, and repairs as well as maintenance of the storage facilities. It is also estimated that labor costs will approach $3,640 annually for collector-operator (1,040 hours at $3.50 per hour). Collectively, costs of this internal system are expected to approach $6,320 annually or about $28 per dwelling unit, in addition to municipal costs of $24 for haul and disposal and $12 for containers and accessories. Quantities collected (28 cubic yards daily or 140 cubic yards weekly) and deposited at the intermediate storage points would require a minimum of twice weekly pickup by the municipality. Cost of such municipal collection (necessary rehandling of bagged materials) together with haul and disposal of the loose bagged wastes from these storage yards would not be expected to be materially reduced from the $24 annual dwelling unit charge or the annual cost of $5,424. By comparison, minimum rates from private contractors could be expected at about $0.75 per cubic yard or $5,460 annually, only if containerized for mechanical loading. Bin containerization not provided in this system is investigated in System 2c.

System 2c--Occupants are required to deposit accumulated wastes in bins centrally located in clusters. Multipurpose utility vehicles will tow these bins to intermediate storage locations. This transfer would also be handled by management's general maintenance service.

This system, handling the same quantities of wastes described in System 2b, would require about 20 conveniently located storage stations, each equipped with a 2 to 3 cubic yard mobile bins. It is estimated that a properly equipped collector operator could move these bins to one or more centrally located service points and return the emptied bins in an average period of two hours daily.

The capital investment required for this system is estimated at about $4,750 (based on an allowance of 25 percent for vehicular cost of $3,000 plus 20 storage containers at about $200 each). Considering a five year life expectancy on vehicular equipment and ten years on mobile storage bins, an equivalent annual capital cost (amortization of principal and interest) of about $720 can be expected. In addition to this cost, an estimated expense of about an equal amount should be allowed for vehicular equipment operation, maintenance and repairs as well as maintenance of the storage units. Labor costs will be about $1,820 (520 hrs at $3.50 per hour). Collectively, annual costs of this internal system are expected to be about $3,260 or under $15 per dwelling unit, in addition to estimated minimum contract costs of $5,460 (for haul and disposal) or $24 per dwelling unit and $12 per dwelling unit for containers and accessories. In the latter case the resident must still provide containers with liners for transporting packaged wastes to the storage bins.

System No. 3 (console compactor stations) is considered for use in the clustered low-rise single family attached and low-rise multifamily units. The occupants are required to deposit accumulated wastes in the hoppers of these compactors and actuate the compaction cycle. Management's maintenance personnel would be required to service these units twice daily or as required. A minimum collection frequency of once weekly would be required although a daily haul and disposal contract would be preferred. Based on the conceptual site plan, it is estimated that about 16 stations could be situated within the complex clusters to provide reasonably convenient access to these 206 dwelling units or an average of about 13 dwellings per compactor station. Initial capital investment of installed equipment is estimated at about $2,000 per station or $32,000. With a life expectancy of about ten years, an equivalent annual capital expense of about $4,400 will be incurred. Materials and supplies (box liners, bag liners, cleaning and disinfectant) and other operating costs (power, lubricants, maintenance, and repairs) of this equipment are estimated at $2 per day per station or about $11,680 per year. Labor costs for servicing this equipment by management personnel are estimated at $14 (4 hrs at $3.50) daily (7-day basis) or $5,100 per year. Collectively, the annual costs of this system are estimated at $21,180 or about $104 per dwelling unit in addition to the estimated haul and disposal contract cost of $18 per dwelling unit and $12 for containers and accessories in the dwelling unit.

System No. 4 considers the use of separate chute-fed stationary baler installations in the medium- and high-rise buildings. Initial capital investment for equipment for the two installations is expected to approach $10,000. With a life expectancy of about ten years, an equivalent annual capital expense (amortization of principal and interest) of about $1,360 will be incurred. Materials and supplies (bale liners, ties, cleaning, and disinfectants) and other operating costs (power, lubricants, maintenance, and repairs) are estimated to average about $2 per day per station or about $1,460 per year. Labor costs for servicing this equipment by management personnel are estimated at $7 (2 hrs at $3.50) daily (7-day basis) or $2,555 per year. Collectively, the annual costs of this system are estimated at $5,000 for the 79 dwelling units, or about $68 per dwelling unit, in addition to the estimated haul and disposal contract cost of $18 per dwelling unit and $12 for containers and accessories.

System 9 considers the use of undercounter compactors in all (226) low-rise dwelling units. Allowing an installed unit cost of $190, a total capital investment of about $42,940 will be required. With an estimated life expectancy of about ten years an equivalent annual capital expense (amortization of principal and interest) of about $5,840 or $26 per dwelling unit will be incurred. Materials and supplies (liners, disinfectants, etc.) and other operating costs to be incurred directly by the dwelling unit occupants will be about $33 per year per unit or a total of $7,458. Occupants of clustered units would be required to deposit packaged wastes in intermediate storage points within each cluster. With this system, collection of this packaged material could be made once weekly with a satellite collection vehicle or multipurpose maintenance equipment, with transfer to intermediate storage locations. Cost of equipment for intermediate storage as well as labor, vehicular equipment and equipment operating costs for transfer of wastes to a central collection point would be about the same as required for System 2c. Estimated cost of this internal collection service would be about $3,260 or $14 per dwelling unit per year. Collectively, the annual costs of this system are estimated at about $73 per dwelling unit in addition to the estimated contract costs of $18 per dwelling unit for haul and disposal.

Evaluation of Candidate Systems: The evaluation of these candidate systems involved both the comparison of systems characteristics and economics of the respective systems installations.

The evaluation of system characteristics (Table 5) provides a deficiency rating of all pertinent characteristics in the sub-systems and the total deficiency rating of each system. Comparisons of these individual ratings between systems provide guidelines for the selection of the system(s) which may be more desirable for the respective types of dwelling units in the project. This method of ranking indicates that System No. 1 should be considered for all dwelling units and supplemented by System No. 9 in the low-rise structures and System No. 4 in the medium- and high-rise structures.

The economic summary (Table 8) of these candidate systems illustrates the comparison of initial capital costs and total annual costs of each as well as equivalent dwelling unit costs for the respective types of dwellings.

Relating system costs and deficiency ratings to the program objectives indicate a combination of Systems No. 1, 4, and 9 are the most suitable selections for the project, requiring an initial capital investment of about $95,725 with total annual costs of $35,081 or about $115 per year or $9.60 per month per dwelling unit.

TABLE 8

ECONOMIC EVALUATION OF SOLID WASTE SYSTEM ALTERNATIVES - MACON, GEORGIA

System No.	Dwelling Units		Capital Cost	Annual Operating Cost				Amortization of Capital Investment	Total Annual Cost	
	Type	No.		Labor	Other Operating Costs	Municipal or Contract Costs	Total		Project	Per Du
*1	All Du's	305	$38,125	-	$ 1,525	-	$ 1,525	$ 5,185	$ 6,710	$ 22
2a	All LR	226	-	-	2,712	$5,424	8,136	-	8,136	36
2b	All LR	226	5,100	$3,640	4,212	5,424	13,276	1,180	14,276	63
2c	All LR	226	4,750	1,820	3,432	5,460	10,712	720	11,432	51
3	LR SFA MF	206	32,000	5,100	14,140	3,690	22,930	4,400	27,330	134
*4	All MR HR	79	10,000	2,555	2,408	1,422	6,385	1,360	7,745	98
*9	All LR	226	47,600	1,820	8,178	4,068	14,066	6,560	20,626	91
*Combination of Recommended Systems										
1,4, &9			$95,725	$4,375	$12,111	$5,490	$21,976	$13,105	$35,081	$115

Memphis, Tennessee

The Memphis Operation Breakthrough development to be situated on a 12-acre elongated parcel will contain 476 dwelling units, including 82 single family attached, 102 low-rise multifamily, and 292 high-rise multifamily units. The single family attached structures are grouped in the eastern portion of the site. Low-rise multifamily structures are grouped in four principal clusters in the western portion of the site together with two high-rise structures.

This urban site is surrounded by light industrial, small warehousing, and supply houses. However, it is also situated within walking distance of the central business district and the Mid-South Medical Center complex. Initial planning studies indicated a strong market potential existed due to this location and relatively high density development was warranted. Site planners concluded that, with high densities, economic support for more amenities existed at lower unit development costs. Development concepts established that vehicular and pedestrian conflicts should be avoided and that ground space occupied by buildings, streets, and parking should be recaptured and made available for more amenable uses.

These basic concepts are obvious in the final design. Vehicular service access and parking for the eastern portion of the site is limited to private roadways (on grade) on the north and south boundaries of this parcel. In the westerly portion of the site, vehicular access is limited to an inner court area (on grade) occupying the majority of open space between the clustered low-rise structures and high-rise structures. This service and parking area is covered by an elevated deck that contains recreational areas and pedestrian ways. The low-rise structures are situated on an intermediate grade between the service level and upper deck. Ramps and stairs provide access to these areas from the low-rise clusters. Elevators and stairs provide access from the high-rise buildings. Functions beneath the deck, in addition to vehicular movement and parking, will include all building services and auxiliary storage for occupants.

The initial planning study, site plan (dated 24 July 1970), and Task II interim report (dated 27 July 1970), prepared by Miller, Wihry and Brooks, Landscape Architects and Engineers, Louis and Henry, Architects and Associates, and Stephen Sussna Associates, Planners, are the bases for this study of solid waste systems for this project.

Estimated Quantities and Types of Wastes to be Handled: Based upon the estimated resident population of 1,528 and a nominal waste production factor of 4 lbs per capita per day, it is expected that average daily waste production will be approximately 6,000 lbs. Distribution of this waste material by type and source of generation is estimated as follows:

Type of Waste	Garbage	Rubbish	Trash	Total
Daily Per Capita Production (lbs)	0.5	3.0	0.5	4.0
Total Daily Production (lbs)	764	4,584	764	6,112
Distribution of Total Daily Production:				
Dwelling Units (lbs)	764	4,124	-	4,888
Ancillary Areas (lbs)	-	230	-	230
Outdoor Common Areas (lbs)	-	230	764	994

It is anticipated that about 10.5 lbs of waste will be generated within the average dwelling unit (average 3.2 persons) each day and will consist of 1.5 lbs of garbage, with a balance of about 9.5 lbs of mixed wastes for separate storage, collection, and disposal.

Available Municipal Services: City provides backyard collection for all residences at a charge of $2.50 per month included on the utility bill. For apartment houses of five or more units, the charge is $2 per unit per month but all waste must be in standard cans or bags. No bulk containers are serviced. No commercial service is provided. Satellite vehicles are used for twice per week collection.

Private collection is available for bulk collection of almost any kind and is used at most apartment houses, and all of the Memphis Housing Authority developments. A typical charge for an apartment house is $1.80 per unit per month. Service to a central compaction station at a single collection point at this site could be provided by contract with an expected cost of $1 to $1.50 per dwelling unit per month. No charge is made by the city to those using private collection service.

Selection of Candidate Systems: Basic systems that are compatible with the physical characteristics of this proposed development and the general program objectives of Operation Breakthrough are limited to the following:

82 Low-rise single family attached	Systems No. 1, 2, 3, and 9
102 Low-rise multifamily	Systems No. 1, 2, 3, and 9
292 High-rise multifamily	Systems No. 1, 4, 5, and 6

System No. 1 (garbage grinders) is desirable for installation in all dwelling units. Allowing an installed unit cost of $125, a total capital investment of about $59,500 will be required for the 476 dwelling units in this project. With a life expectancy of ten years and including capital expense maintenance, repairs, and operating costs, a total annual cost of about $22 is expected to be incurred by the occupants of each dwelling unit.

System No. 2 (variations of conventional collection system) may be considered for low-rise dwelling units. These variations are identified as follows:

System 2a--The conventional municipal collection, consisting of house-to-house collection with a conventional packer truck, although in minor conflict with program objectives, is considered for economic comparison. Use of this system would be limited to the 82 townhouses in the east block. This system would not require capital investment on the part of the developer and would cost the dwelling unit owner or occupant about $24 annually for service and an additional cost of about $12 annually for containers and accessories.

System 2b--House-to-house collection service twice weekly for all (184) low-rise units, using either a satellite collection vehicle or multipurpose maintenance vehicle for transfer of collected waste materials to intermediate storage locations, may be considered as an alternate to the above. The following cost estimate of capital investment in equipment, equivalent annual capital costs, operating costs, and labor are proportionate to the dwelling unit costs as determined in the preceding Macon study. It is estimated that capital investment in equipment will be about $4,150. Considering a five-year life expectancy on such experiment, an equivalent annual capital cost of about $970 can be expected in addition to an estimated expense of $1,220 annually in equipment operation, maintenance, and repairs. It is also estimated that labor costs will approach $2,960 (845 hrs at $3.50 per hour) annually for the collector-operator. Collectively, costs of this internal system are expected to approach $5,150 annually or about $28 per dwelling unit, in addition to costs of up to $18 for haul and disposal and $12 for containers and accessories.

System 2c--Occupants are required to deposit accumulated wastes in bins centrally located in clusters. Multipurpose utility vehicles will tow these bins to intermediate storage locations. This transfer would also be handled by management's general maintenance service. As in the case of the above, costs of this system are proportionate to the dwelling unit costs as determined in the Macon study. It is estimated that such service could be provided for an annual cost of about $2,660 or $15 per dwelling unit, in addition to costs of up to $18 for haul and disposal and $12 for containers and accessories.

System No. 3 (console compactor stations) is considered for use in the clustered low-rise units. The occupants are required to deposit accumulated wastes in the hoppers of these compactors and actuate the compaction cycle. Management's maintenance personnel would be required to service these units twice daily or as required. A minimum collection frequency of once weekly would be required. Based on the conceptual site plan, it is estimated that about 14 stations could be situated within the complex clusters to provide reasonably convenient access to these 184 dwelling units or an average of about 13 dwellings per compactor station. Initial capital investment of installed equipment is estimated at about \$2,000 per station or \$28,000. With a life expectancy of about ten years, an equivalent annual capital expense of about \$3,800 will be incurred. Materials, supplies, and other operating costs of this equipment are estimated at \$2 per day per station or about \$10,200 per year. Labor costs for servicing this equipment by management personnel are estimated at \$10.50 (3 hrs at \$3.50) daily (7-day basis) or about \$3,800 per year. Collectively, the annual costs of this system are estimated at \$17,800 or about \$97 per dwelling unit in addition to an estimated cost of \$18 for haul and disposal and \$12 for containers and accessories in the dwelling unit.

System No. 4 considers the use of separate chute-fed stationary baler installations in each of the high-rise buildings. Initial capital investment for equipment for the two installations is expected to approach $15,000. With a life expectancy of about ten years, an equivalent annual capital expense of about $2,040 will be incurred. Materials, supplies, and other operating costs are estimated to average about $6 per day per station or about $4,380 per year. Labor costs for servicing this equipment by management personnel are estimated at $17.50 (5 hrs at $3.50) daily (7-day basis) or $6,400 per year. Collectively, the annual costs of this system are estimated at $12,820 for the 292 dwelling units, or about $44 per dwelling unit, in addition to an estimated minimum cost of $12 for haul and disposal and $12 for containers and accessories.

System No. 6 considers the use of a pneumatic waste collection system serving all dwelling units in this project. The collector conduit or pipeline will interface with gravity chutes, in the high-rise structures and should contain about 14 remote charging stations conveniently located to the clustered housing. Wastes will be transported to a centrally located compactor station for processing and storage. Based on preliminary estimates, the pneumatic system is expected to cost about $500,000. With a life expectancy of about 50 years (amortization rate of 0.0635) the equivalent annual capital expense will be about $31,800. The cost of the central compactor station is expected to approach $20,000 and with a life expectancy of ten years (amortization rate of 0.1360) the equivalent annual capital expense will be about $2,720.

Manufacturers of the pneumatic system estimate that annual maintenance, repairs, operating labor, and other operating costs will be equivalent to about 1 percent of the installed cost of $5,200. Collectively, the annual costs of this system are estimated at $42,275 or about $89 per dwelling unit in addition to an estimated minimum cost of $12 (per dwelling unit) for haul and disposal and $12 for containers and accessories in the dwelling unit.

System No. 9 considers the use of under-counter compactors in all (184) low-rise dwelling units. Allowing an installed unit cost of $190, a total capital investment of about $34,960 will be required. With an estimated life expectancy of about 10 years, an equivalent annual capital expense of about $4,780 or $26 per dwelling unit will be incurred. Materials, supplies, and other operating costs to be incurred directly by the dwelling unit occupants will be about $33 per year per unit or a total of $6,077. Occupants of clustered units would be required to deposit packaged wastes in intermediate storage points within each cluster. Using this system, collection of the packaged material could be made once weekly with a satellite collection vehicle or multipurpose maintenance equipment, with transfer to intermediate storage locations. Estimated cost of this type of internal collection service, based upon dwelling unit costs determined in the Macon study, would be about $2,640 or $14 per dwelling unit per year. Collectively, the annual costs of this system are estimated at about $73 per dwelling unit in addition to an estimated minimum cost of $18 for haul and disposal.

Evaluation of Candidate Systems: The evaluation of these candidate systems involved both the comparison of systems characteristics and economics of the respective systems installations.

The evaluation of system characteristics (Table 5) provides a deficiency rating of all pertinent characteristics in the sub-systems and the total deficiency rating of each system. Comparisons of these individual ratings between systems provide guidelines for the selection of the system(s) which may be more desirable for the respective types of dwelling units in the project. This method of ranking indicates that Systems No. 1 and 6 should be considered for all dwelling units. Alternatively System No. 1 could be supplemented by a combination of

System No. 9 in the low-rise structures and System No. 4 in the high-rise structures.

The economic summary (Table 9) of these candidate systems illustrates the comparison of initial capital costs and total annual costs of each as well as equivalent dwelling unit costs for the respective types of dwellings.

Relating system costs and deficiency ratings to the program objectives indicate that the combination of Systems No. 1 and 6 would offer the highest level of service in the inter-unit and inter-building systems benefiting the project at large. Although it is estimated that a large capital investment ($579,500) would be required, annual dwelling unit costs ($135 per dwelling unit or about $11.25 per month) would not be significantly higher than costs of other combinations of systems where an improved level of service can be obtained.

By comparison, a combination of Systems No. 1, 4, and 9, also a suitable selection for the project, would require an initial capital investment of about $120,500 with total annual costs of about $47,109 or $99 per dwelling unit per year or about $8.35 per month.

TABLE 9

ECONOMIC EVALUATION OF SOLID WASTE SYSTEM ALTERNATIVES - MEMPHIS, TENNESSEE

System No.	Dwelling Units		Capital Cost	Annual Operating Cost				Amortization of Capital Investment	Total Annual Cost	
	Type	No.		Labor	Other Operating Costs	Municipal or Contract Costs	Total		Project	Per Du
*1	All Du's	476	$ 59,500	-	$ 2,380	-	$ 2,380	$ 8,092	$10,472	$ 22
2a	All LR	82	-	-	984	$1,968	2,952	-	2,952	36
2b	All LR	184	4,150	$2,960	3,428	3,312	9,709	970	10,670	58
2c	All LR	184	3,850	1,480	2,798	3,312	7,590	590	8,180	45
3	All LR	184	28,000	3,800	12,408	3,312	19,520	3,800	23,320	127
*4	MR & HR	292	15,000	6,400	7,884	3,504	17,788	2,040	19,828	68
*6	All Du's	476	520,000	2,555	10,912	5,712	19,179	34,520	53,699	113
*9	All LR	184	46,000	1,480	6,657	3,312	11,449	5,360	16,809	91
*Combination of Recommended Systems										
1,4,&9		476	120,500	7,880	16,921	6,816	31,617	15,492	47,109	99
1 &6		476	579,500	2,555	13,292	5,712	21,559	42,612	64,171	135

St. Louis, Missouri

The Operation Breakthrough development in St. Louis will contain a total of 463 dwelling units on two non-contiguous sites. These sites are separated by an existing 600-unit housing development (Laclede Town) developed and managed by the same site developer selected for the Operation Breakthrough development.

A 7.6-acre site east of Laclede Town will contain 241 dwelling units. These multifamily apartment buildings, ranging from three to ten stories in height, are to be grouped in a campus-like setting. All of the ground floor apartments will have private patios. Seven low-rise buildings share common stairways. Four additional low-rise buildings are free-standing, as are the medium-rise and high-rise buildings. Recreational facilities are located on the northerly boundary of the site. Vehicular access and parking is limited to four conveniently located parking courts on the perimeter of the site.

An 8-acre parcel west of Laclede Town will contain 222 dwelling units, including 75 low-rise single family attached, 50-low rise multifamily, 25 medium-rise multifamily, and 72 high-rise multifamily units. Buildings are grouped in five major clusters. The multifamily apartments are contained in one large grouping oriented to an inner recreational courtyard with a swimming pool. Vehicular access and parking is situated on three sides of the perimeter of this group. Single family attached units are grouped in four additional clusters. Buildings in each of these clusters are oriented to an inner landscaped courtyard. Each dwelling unit has a private patio oriented to the street or parking court. Vehicular access and service is limited to four parking courts and access drives.

Site Planners initially established the following program objectives preceding the development of this design:

1. Develop intensive pedestrian community space as the major organizational element.
2. Maximize potential for private outdoor space.
3. Minimize automobile intrusion but maximize its convenience:
   (a) Maximum walking distance from car to front door--200 ft.
   (b) Automobile to be kept out of pedestrian precincts.
4. Public neighborhood places should be easily accessible and visible to residents.
5. Small children should have safe, secure, easily surveiled places to play.
6. Pedestrian circulation should be designed to allow for convenient pathways to off-site community facilities.
7. Maximize use of large hardy trees as the main vegetation.

8. All age groups should have their own identifiable outdoor space.

10. Provide some unassigned outdoor places.

The initial planning study, as prepared by Hellmuth, Obata and Kassabaum, Inc., Architects, Landscape Architects, and Engineers, St. Louis, Missouri, together with the site plan (received 26 October 1970) are the principal bases for this study of solid waste systems for this project.

Estimated Quantities and Types of Wastes to be Handled: Waste projections for the St. Louis development have been calculated separately for the East and West Sites. Based upon an estimated resident population of 720 for the East Site, and a nominal waste production factor of 4 lbs per capita per day, it is expected that average daily waste production will approach 3,000 lbs. Distribution of this waste material by type and source of generation is estimated as follows:

Type of Waste	Garbage	Rubbish	Trash	Total
Daily Per Capita Production (lbs)	0.5	3.0	0.5	4.0
Total Daily Production (lbs)	360	2,160	360	2,880
Distribution of Total Daily Production:				
Dwelling Units (lbs)	360	1,944	-	2,304

Ancillary Areas (lbs)	-	108	-	108
Outdoor Common Areas (lbs)	-	108	360	468

It is anticipated that about 9.5 lbs of wastes will be generated within the average dwelling unit (average 3.0 persons) each day, and will consist of approximately 1.5 lbs of garbage, with a balance of about 8 lbs of mixed wastes for separate storage, collection, and disposal.

Based upon an estimated population of 805 for the West Site, and assuming similar waste production factors, a daily average of 3,200 lbs of waste materials may be generated. Distribution of this material is estimated as follows:

Type of Waste	Garbage	Rubbish	Trash	Total
Daily Per Capita Production (lbs)	0.5	4.15	0.5	4.0
Total Daily Production (lbs)	402	2,415	403	3,220
Distribution of Total Daily Production:				
Dwelling Units (lbs)	402	2,175	-	2,577
Ancillary Areas (lbs)	-	120	-	120

Outdoor Common Areas (lbs)	-	120	-	523

It is anticipated that about 11.5 lbs of waste will be generated within the average dwelling unit (average 3.6 persons) each day and will consist of approximately 1.8 lbs of garbage, with a balance of about 9.7 lbs of mixed wastes for separate storage, collection, and disposal.

Available Municipal Services: The city provides twice a week collection from residences only and no direct charge is made. However for purposes of this study an allowance of $24 per dwelling unit per year has been adopted for conventional haul and disposal services furnished by the municipality. No bulk containers are serviced and waste must be in 20-26 gallon containers. Collection is provided from alleys (where they are maneuverable) or from curbside and only 20 cubic yard packer trucks are used. Heavy trucks are not permitted on private streets.

At Laclede Town, separating the east and west sites, door to door collection of solid waste in plastic or paper bags is provided daily by the developer who places the bags at a central storage point. The city then picks up the bags from the storage area. Although costs of management furnished collection service was not made available, it was determined that two collector-operators each equipped with tractor drawn trailer rigs were required to perform this service. It was also indicated that a 40-hour week for both operators was normally required. Annual costs of this management service for approximately 600 dwelling units in Laclede Town are estimated at about $19,280 or $32 per dwelling unit in addition to the occupants cost of containers and accessories as well as costs of haul and disposal incurred by the tax payers. Costs of this management service are based on estimated labor costs of $14,560 (4,160 hrs at $3.50 per hour), capital costs of equipment at $1,600 annually (2 tractor trailer units at $3,500 = $7,000 amortized over 5 years at annual rate of 0.2375) and vehicular operating costs of $3,120 (4,160 hrs at $0.75 per hour).

Solid waste collection for low-rise dwelling units at the Operation Breakthrough site could be handled in the same manner as Laclede Town, especially since they will probably be under the same management. If the streets or the site are public, however, city trucks could collect on the site from curbside.

Selection of Candidate Systems--East Site: Basic systems that are compatible with the various types of dwelling units, other physical characteristics of this proposed development, and the general program objectives of Operation Breakthrough are limited to the following:

130 Low-rise multifamily	Systems No. 1, 2, 3, and 9
27 Medium-rise multifamily	Systems No. 1 and 4
84 High-rise multifamily	Systems No. 1 and 4

Sustem No. 1 (garbage grinders) is desirable for installation in all dwelling units. Allowing an installed unit cost of $125, a total capital investment of about $30,125 will be required for the 241 dwelling units at this site. With a life expectancy of 10 years and including maintenance, repairs, and operating costs, a total annual cost of about $22 is expected to be incurred by the occupants of each dwelling unit.

System No. 2 (variations of conventional collection system) may be considered for all (130) low-rise multifamily dwelling units at this site.

System 2a--The conventional municipal collection system consisting of house-to-house collection with a conventional packer truck or

System 2b--House-to-house collection service, using either a satellite collection vehicle or multipurpose maintenance vehicle for transfer of collected waste materials to intermediate storage locations does not appear feasible at this site.

System 2c--Where occupants are required to deposit accumulated wastes in centrally located bins is the only variation which appears to be compatible, other than the present system used in Laclede Town. In System 2c multipurpose utility vehicles will tow these bins to intermediate storage locations. This transfer would be handled by management's general maintenance service and would also be compatible with the waste system provided at Laclede Town. It is estimated that such service could be provided for about $2,070 annually or $16 per dwelling unit in addition to estimated minimum costs of $24 for haul and disposal and $12 for containers and accessories. The costs for internal service are generally proportionate to the dwelling unit costs as found in the Macon study. Annual labor costs are estimated at $1,050 (300 hrs at $3.50 per hour), other annual operating costs at $380, and an equivalent annual cost of equipment at about $640.

System No. 3 (console compactor stations) is considered for use in the low-rise multifamily units. The occupants are required to deposit accumulated wastes in the hoppers of these compactors and actuate the compaction cycle. Management's maintenance personnel would be required to service these units twice daily or as required. A minimum collection frequency of once weekly would be required. Based on the conceptual site plan, it is estimated that about 8 stations could be situated within the complex clusters to provide reasonably convenient access to these 130 dwelling units or an average of about 16 dwellings per compactor station. Initial capital investment of installed equipment is estimated at about $2,000 per station or $16,000. With a life expectancy of about 10 years, an equivalent annual capital expense of about $2,160 will be incurred. Materials, supplies, and other operating costs of this equipment are estimated at $2 per day per station or about $5,840 per year. Labor costs for servicing this equipment by management personnel are estimated at $7 (2 hrs at $3.50) daily (7-day basis) or $2,555 per year. Collectively, the annual costs of this system are estimated at $10,555 or about $81 per dwelling unit in addition to an estimated minimum cost of $18 for haul and disposal and $12 for containers and accessories in the dwelling unit.

System No. 4 considers the use of separate chute-fed stationary baler installations in the medium- and high-rise buildings. Initial capital investment for equipment for the two installations is expected to approach $10,000. With a life expectancy of about 10 years, an equivalent annual capital expense of about $1,360 will be incurred. Materials, supplies, and other operating costs are estimated to average about $2 per day per station or about $1,460 per year. Labor costs for servicing this equipment by management personnel are estimated at $7 (2 hrs at $3.50) daily (7-day basis) or $2,555 per year. Collectively, the annual costs of this system are estimated at $5,375 for the 111 dwelling units or about $48 per dwelling unit, in addition to an estimated minimum cost of $18 per dwelling unit for haul and disposal and $12 for containers and accessories.

System 9 considers the use of under-counter compactors in all 130 low-rise dwelling units. Allowing an installed unit cost of $190, a total capital investment of about $24,700 will be required. With an estimated life expectancy of about 10 years, an equivalent annual capital expense of about $26 per dwelling unit will be incurred. Materials, supplies, and other operating costs to be incurred directly by the dwelling unit occupants will approach $33 per year per unit or a total of $4,290. Occupants of these dwelling units would be required to deposit packaged wastes in centrally located storage bins. With this system, collection of this packaged material could be made once weekly with a satellite collection vehicle or multipurpose maintenance equipment, with transfer to an intermediate storage location. Estimated cost of this internal collection service would be comparable to those costs as shown in System 2c or about $2,070 ($16 per dwelling unit per year). Collectively, the annual costs of this system are estimated at $9,800 or about $76 per dwelling unit in addition to the estimated minimum cost of $18 for haul and disposal.

Selection of Candidate Systems--West Site: Basic systems that are compatible with dwelling unit types, other physical characteristics of this proposed development, and the general program objectives of Operation

Breakthrough are limited to the following:

75 Low-rise single family attached	Systems No. 1, 2, 3, and 9
50 Low-rise multifamily	Systems No. 1, 2, 3, and 9
25 Medium-rise multifamily	Systems No. 1 and 4
72 High-rise multifamily	Systems No. 1 and 4

System No. 1 (garbage grinders) is desirable for installation in all dwelling units. Allowing an installed unit cost of $125, a total capital investment of about $27,750 will be required for the 222 dwelling units in this project. With a life expectancy of 10 years and including maintenance, repairs, and operating costs, a total annual cost of about $22 is expected to be incurred by the occupants of each dwelling unit.

System No. 2 (variations of conventional collection system) may be considered for all 125 low-rise dwelling units. These variations are identified as follows:

System 2a--The conventional municipal collection, consisting of curbside collection with a conventional packer track, although in minor conflict with program objectives, is considered for economic comparison. The cost of this system, requiring no capital investment on the part of the developer, will be limited to the estimated minimum indirect cost of $24 per dwelling unit for haul and disposal service and an additional cost of about $12 annually for containers and accessories.

System 2b--Curbside collection service twice weekly, using either a satellite collection vehicle or multipurpose maintenance, a vehicle for transfer of collected waste materials to intermediate storage locations may be considered as an alternate to the above. Costs of this system are proportionate to the dwelling unit costs as determined in the Macon study. It is estimated that capital investment in vehicular equipment and storage facilities will be about $2,600. Considering a 5-year life expectancy on such equipment, an equivalent annual capital cost of about $640 can be expected in addition to an estimated expense of $825 annually in equipment operation, maintenance, and repairs. It is also estimated that labor costs will approach $2,000 (570 hrs at $3.50 per hour) annually for the collector-operator. Collectively, costs of this internal system are expected to approach $3,475 annually or about $28 per dwelling unit, in addition to the estimated minimum indirect costs of $24 for haul and disposal and $12 for containers and accessories.

System 2c--Occupants are required to deposit accumulated wastes in bins centrally located in clusters. Multipurpose utility vehicles will tow these bins to intermediate storage locations. This transfer would be handled by management's general maintenance service and would be compatible with the waste system provided at Laclede town. It is estimated that such service could be provided with about the same equipment and labor requirements of System 2c at the East Site or for an annual cost of about $2,070 or $16 per dwelling unit, in addition to the estimated minimum costs of $24 for haul and disposal and $12 for containers and accessories.

System No. 3 (console compactor stations) is considered for use in the clustered low-rise single family attached and low-rise multifamily units. The occupants are required to deposit accumulated wastes in the hoppers of these compactors and actuate the compaction cycle. Management's maintenance personnel would be required to service these units twice daily or as required. A minimum collection frequency of once weekly would be required. Based on the conceptual site plan, it is estimated that about 9 stations could be situated within the complex clusters to provide reasonably convenient access to these 125 dwelling units or an average of about 14 dwellings per compactor station. Initial capital investment of installed equipment is estimated at about $2,000 per station or $18,000. With a life expectancy of about 10 years, an equivalent annual capital expense of about $2,440 will be incurred. Materials, supplies, and other operating costs of this equipment are estimated at $2 per day per station or about $6,570 per year. Labor costs for servicing ths equipment by management personnel are estimated at $7 (2 hrs at $3.50) daily (7-day basis) or $2,555 per year.

Collectively, the annual costs of this system are estimated at $11,565 or about $92 per dwelling unit in addition to the estimated minimum cost of $18 for haul and disposal and $12 for containers and accessories in the dwelling unit.

System No. 4 considers the use of separate chute-fed stationary baler installations in the medium- and high-rise buildings. Initial capital investment for equipment for two installations and costs of operation are expected to be equivalent to the two installations at East Site. Collectively, the annual costs of this system are estimated at $5,375 for the 97 dwelling units, or about $56 per dwelling unit, in addition to the estimated minimum cost of $18 for haul and disposal and $12 for containers and accessories.

System No. 9 considers the use of under-counter compactors in all (125) low-rise dwelling units. Allowing an installed unit cost of $190, a total capital investment of about $23,750 will be required. With an estimated life expectancy of about 10 years, an equivalent annual capital expense of about $26 per dwelling unit will be incurred. Materials, supplies, and other operating costs to be incurred directly by the dwelling unit occupants will approach $33 per year per unit or a total of $4,125. Occupants of clustered units would be required to deposit packaged wastes in centrally located storage bins within each cluster. With this system, collection of this packaged material could be made once weekly with a satellite collection vehicle or multipurpose maintenance equipment, with transfer to an intermediate storage location. Estimated cost of this internal collection service would be comparable to those costs shown in System 2c or about $2,070 ($16 per dwelling unit per year). Collectively, the annual costs of this system are estimated at about $9,445 or $75 per dwelling unit in addition to the estimated minimum cost of $18 for haul and disposal.

Evaluation of Candidate Systems: The evaluation of these candidate systems involved both the comparison of system characteristics and economics of the respective systems installations.

The evaluation of system characteristics (Table 5) provides a deficiency rating of all pertinent characteristics in the sub-systems and the total deficiency rating of each system. Comparisons of these individual ratings between systems provide guidelines for the selection of the system(s) which may be more desirable for the respective types of dwelling units in the project. This method of ranking indicates that System No. 1 should be considered for all dwelling units and supplemented by System No. 9 in the low-rise structures and System No. 4 in the medium- and high-rise structures at both the East and West Sites.

The economic summary (Tables 10 and 11) of these candidate systems for both sites illustrates the comparison of initial capital costs and total annual costs of each as well as equivalent dwelling unit costs for the respective types of dwellings.

Relating system costs and deficiency ratings to the program objectives indicate that a combination of Systems No. 1, 4, and 9 is the most suitable selection for the project, requiring a total initial capital investment of about $131,525 with total annual costs of $51,053 or about $111 per year or $9.25 per month per dwelling unit.

TABLE 10

ECONOMIC EVALUATION OF SOLID WASTE SYSTEM ALTERNATIVES - ST. LOUIS, MISSOURI - EAST SITE

System No.	Dwelling Units		Capital Cost	Annual Operating Cost				Amortization of Capital Investment	Total Annual Cost	
	Type	No.		Labor	Other Operating Costs	Municipal or Contract Costs	Total		Project	Per Du
*1	All Du's	241	$30,125	-	$1,205	-	$ 1,205	$4,097	$ 5,302	$ 22
2c	All LR	130	2,730	$1,050	1,940	$3,120	6,110	640	6,750	52
3	All LR	130	16,000	2,555	7,400	2,340	12,295	2,160	14,455	111
*4	MR HR	111	10,000	2,555	2,792	1,998	7,347	1,360	8,707	78
*9	All LR	130	27,300	1,050	4,670	2,340	8,060	4,020	12,080	93
*Combination of Recommended Systems										
1,4, & 9		241	$67,425	$3,605	$8,667	$4,338	$16,612	$9,477	$26,089	$108

TABLE 11

ECONOMIC EVALUATION OF SOLID WASTE SYSTEM ALTERNATIVES - ST. LOUIS, MISSOURI - WEST SITE

System No.	Dwelling Units		Capital Cost	Annual Operating Cost				Amortization of Capital Investment	Total Annual Cost	
	Type	No.		Labor	Other Operating Costs	Municipal or Contract Costs	Total		Project	Per Du
*1	All Du's	222	$27,750	-	$1,110	-	$ 1,110	$3,774	$ 4,884	$ 22
2a	All LR	125	-	-	1,500	$3,000	4,500	-	4,500	36
2b	All LR	125	2,800	$2,000	3,325	3,000	7,325	650	7,975	63
2c	All LR	125	2,730	1,050	1,880	3,000	5,930	640	6,570	52
3	All LR	125	18,000	2,555	8,070	2,250	12,875	2,440	15,315	122
*4	MR HR	97	10,000	2,555	2,624	1,846	7,025	1,360	8,385	86
*9	All LR	125	26,350	1,050	4,505	2,250	7,805	3,890	11,695	93
1,4, & 9		222	$64,100	$3,605	$8,239	$4,096	$15,940	$9,024	$24,964	$112

*Combination of Recommended Systems

Indianapolis, Indiana

The Indianapolis Operation Breakthrough development will be situated within a 120-acre parcel that was formerly a state farm complex. This prototype housing development will be limited to a parcel of approximately 52 acres generally confined to the southeast quadrant of the total site. A special school for handicapped children is being constructed on a parcel in the northeast quadrant. The balance of the site is being reserved for future housing development to complement the Breakthrough program.

A public school site of four acres has been reserved in the northerly portion of the Breakthrough site, and a 15-acre site at the southeastern corner will be developed in parks, recreational fields, and a community center. The initial Breakthrough housing development will contain 300 dwelling units, including an assumed 113 single family detached, 82 single family attached, and 105 multifamily units (low-rise and medium-rise buildings). The single family detached units are situated along the south and east borders of the site with the single family attached and multifamily units grouped in the interior of the site.

Vehicular traffic to the site is limited to one access street from the east and one from the south. An interior system of minor streets with numerous cul de sacs and common drives branch from these principal access streets. No through streets are provided in the development. Vehicular access and service to all dwelling units is oriented to this interior street system. In addition to the street system, an interior system of pedestrian walks is proposed. It is expected these walks would also accommodate small multipurpose maintenance vehicles that may be required.

The initial planning study as prepared by Skidmore, Owings and Merrill, Urban Designers, Architects, and Engineers, Washington, D.C., together with the Site Plan (dated 19 June 1970) are the principal bases for this study of solid waste systems for this project.

Estimated Quantities and Types of Wastes to be Handled: Based upon the assumed dwelling unit mix, an estimated resident population of 1,230 is expected to generate about 5,000 lbs of wastes daily. Distribution of this waste material by type and source of generation is estimated as follows:

Type of Waste	Garbage	Rubbish	Trash	Total
Daily Per Capita Production (lbs)	0.5	3.0	0.5	4.0
Total Daily Production (lbs)	615	3,690	615	4,920
Distribution of Total Daily Production:				
Dwelling Units (lbs)	615	3,320	-	3,935

Ancillary Areas (lbs)	-	185	-	185
Outdoor Common Areas (lbs)	-	185	615	800

It is anticipated that about 13 lbs of wastes will be generated within the average dwelling unit (average 4.1 persons) each day and will consist of approximately 2 lbs of garbage, with a balance of about 11 lbs of mixed wastes for separate storage, collection, and disposal.

Available Municipal Services: The city provides collection once per week at the property line for all residential dwellings. No commercial service is provided by the city. Waste must be in cans or bags--no bulk container service is provided. Apartment houses are served if cans are used. Licensed private operators are available for bulk container collection.

The cost of collection and disposal is paid through property taxes and no direct charges are made. However for purposes of this study an allowance of $24 per dwelling unit per year has been adopted for conventional haul and disposal services furnished by the municipality.

Selection of Candidate Systems: Basic systems that are compatible with the various types of dwelling units, other physical characteristics of this proposed development and the general program objectives of Operation Breakthrough are limited to the following:

113 Low-rise single family detached	Systems No. 1, 2, and 9
82 Low-rise single family attached	Systems No. 1, 2, 3, and 9
*55 Low-rise multifamily	Systems No. 1, 2, 3, and 9
*50 Medium-rise multifamily	Systems No. 1 and 4

*Estimated from site plan dated 6-19-70

System No. 1 (garbage grinders) is desirable for installation in all dwelling units. Allowing an installed unit cost of $125, a total capital investment of about $37,500 will be required for the 300 dwelling units in this project. With a life expectancy of ten years and including maintenance, repairs, and operating costs, a total annual cost of about $22 is expected to be incurred by the occupants of each dwelling unit.

System No. 2 (variations of conventional collection system) may be considered for all (250) low-rise dwelling units. These variations are identified as follows:

System 2a--Although the conventional municipal system of curbside collection with a conventional packer truck is in minor conflict with program objectives and access for larger vehicles is a problem, it is considered for economic comparison. This system, requiring no capital investment on the part of the developer, will cost the dwelling unit owner or occupant an estimated minimum indirect cost of $24 annually per dwelling unit for service and an additional cost of about $12 annually for containers and accessories.

System 2b--Curbside collection service weekly, using either a satellite collection vehicle or multipurpose maintenance vehicle for transfer of collected waste materials to intermediate storage locations may be considered as an alternate to the above. Costs of this system are proportionate to the dwelling unit costs as determined in the Macon study. It is estimated that capital investment in vehicular equipment and storage facilities will be about $5,610. Considering a five-year life expectancy on such equipment, an equivalent annual capital cost of about $1,340 can be expected in addition to an estimated expense of $1,650 annually in equipment operation, maintenance, and repairs. It is also estimated that labor costs will approach $4,000 annually for the collector-operator. Collectively, costs of this internal system are expected to approach $6,990 annually or about $28 per dwelling unit, in addition to estimated minimum indirect costs of $24 for haul and disposal and $12 for containers and accessories.

System 2c--Occupants of low-rise single family attached and multifamily units are required to deposit accumulated wastes in centrally located bins. Curbside collection of single family detached units will also be provided. Multipurpose utility vehicles will provide all collection and tow these bins to intermediate storage locations. This transfer would also be handled by management's general maintenance service. The costs for internal service are generally proportionate to the dwelling unit costs as determined in the Macon study. It is estimated that capital investment in vehicular equipment and storage bins will be about $5,225, resulting in an equivalent annual capital expense of about $795 and an equal sum for operating costs (including maintenance and repairs) of equipment. In addition, labor costs are estimated at about $1,995 (570 hrs at $3.50 per hour). Collectively, costs of this internal system are expected to be about $3,585 annually or under $15 per dwelling unit, in addition to an estimated minimum cost of $24 per dwelling unit for haul and disposal and $12 for containers and accessories.

System No. 3 (console compactor stations) is considered for use by low-rise single family attached and low-rise multifamily units. The occupants are required to deposit accumulated wastes in the hoppers of these compactors and actuate the compaction cycle. Management's maintenance personnel would be required to service these units twice daily or as required. A minimum collection frequency of once weekly would be required. Based on the conceptual site plan, it is estimated that about 10 stations could be situated within the complex clusters to provide reasonably convenient access to these 137 dwelling units or an average of about 14 dwellings per compactor station. Initial capital investment of installed equipment is estimated at about $2,000 per station or $20,000. With a life expectancy of about ten years, an equivalent annual capital expense of about $2,720 will be incurred. Materials, supplies, and other operating costs of this equipment are estimated at $2 per day per station or about $7,300 per year. Labor costs for servicing this equipment by management personnel are estimated at $7 (2 hrs at $3.50) daily (7-day basis) or $2,555 per year. Collectively, the annual costs of this system are estimated at $12,575 or about $91 per dwelling unit in addition to the estimated cost of $18 per dwelling unit for haul and disposal and $12 for containers and accessories in the dwelling unit.

System No. 4 considers the use of separate chute-fed stationary baler installations in the three medium-rise buildings. Initial capital investment for equipment for the three installations is expected to approach $9,000. With a life expectancy of about ten years, an equivalent annual capital expense of about $1,220 will be incurred. Materials, supplies, and other operating costs are estimated to average about $2 per day per station or about $2,190 per year. Labor costs for servicing this equipment by management personnel are estimated at $3.50 (1 hr at $3.50) daily (7-day basis) or $1,277 per year. Collectively, the annual costs of this system are estimated at $4,687 for the 50 dwelling units, or about $94 per dwelling unit, in addition to the estimated cost of $18 per dwelling unit for haul and disposal and $12 for containers and accessories.

System 9 considers the use of under-counter compactors in all (250) low-rise dwelling units. Allowing an installed unit cost of $190, a total capital investment of about $47,500 will be required. With an estimated life expectancy of about ten years, an equivalent annual capital expense of about $26 per dwelling unit will be incurred. Materials, supplies, and other operating costs to be incurred directly by the dwelling unit occupants will approach $33 per year per unit or a total of $8,250. Occupants of grouped units would be required to deposit packaged wastes in centrally located storage bins. With this system collection of this packaged material could be made once weekly with a satellite collection vehicle or multipurpose maintenance equipment, with transfer to intermediate storage locations. Estimated cost of this internal collection service would be comparable to those costs in System 2c or about $3,585 ($14 per dwelling unit per year). Collectively, the annual costs of this system are estimated at about $73 per dwelling unit in addition to the estimated cost of $18 for haul and disposal.

Evaluation of Candidate Systems: The evaluation of these candidate systems involved both the comparison of systems characteristics and economics of the respective systems installations.

The evaluation of system characteristics (Table 5) provides a deficiency rating of all pertinent characteristics in the sub-systems and the total deficiency rating of each system. Comparisons of these individual ratings between systems provide guidelines for the selection of the system(s) which may be more desirable for the respective types of dwelling units in the project. This method of ranking indicates that System No. 1 should be considered for all dwelling units and supplemented by System No. 9 in the low-rise structures and System No. 4 in the medium-rise structures.

The economic summary (Table 12) of these candidate systems illustrates the comparison of initial capital costs and total annual costs of each as well as equivalent dwelling unit costs for the respective types of dwellings.

Relating system costs and deficiency ratings to the program objectives indicate a combination of Systems No. 1, 4, and 9 are the most suitable selections for the project, requiring an initial capital investment of about $99,225 with total annual costs of about $35,622 or about $119 per year or $9.90 per month per dwelling unit.

TABLE 12

ECONOMIC EVALUATION OF SOLID WASTE SYSTEM ALTERNATIVES - INDIANAPOLIS, INDIANA

System No.	Dwelling Units		Capital Cost	Annual Operating Cost				Amortization of Capital Investment	Total Annual Cost	
	Type	No.		Labor	Other Operating Costs	Municipal or Contract Costs	Total		Project	Per DU
*1	All DU's	300	$ 37,500	-	$ 1,500	-	$ 1,500	$ 5,100	$ 6,600	$ 22
2a	All LR	250	-	-	3,000	$ 6,000	9,000	-	9,000	36
2b	All LR	250	5,610	$ 4,000	4,650	6,000	14,650	1,340	15,990	64
2c	All LR	250	5,225	1,995	3,795	6,000	11,790	795	12,585	51
3	All SFA & MF	137	20,000	2,555	8,944	2,466	13,965	2,720	16,685	121
*4	MR	50	9,000	1,277	2,790	900	4,967	1,220	6,187	124
*9	All LR	250	52,725	1,995	9,045	4,500	15,540	7,295	22,835	91
*	Combination of Recommended Systems									
1, 4, 9		300	$ 99,225	$ 3,272	$13,335	$ 5,400	$22,007	$13,615	$35,622	$119

Kalamazoo, Michigan

The Kalamazoo development, to be situated on a 35-acre irregular shaped parcel, will contain 220 dwelling units, including 18 single family detached, 108 single family attached, and 94 low-rise multifamily units. The site is buffered from public thoroughfares by existing single family housing on the east and south boundaries, low-rise apartment buildings on the west, and Spring Valley Park to the north.

Access streets are provided in the southeast and southwest corners of the site and are linked together with a frontage street along the south border of the property. Recreational areas and a community center are situated on the north side of this street, together with a 48-unit low-rise multifamily apartment building and parking area. The two access streets also continue northward into the property. One terminates in a cul de sac; the other in a parking courtyard. The single family detached units are grouped in two clusters on the east side of the site and are served by common drives from the access street. The balance of the low-rise multifamily units and all single family attached units are grouped in seven clusters. Vehicular access and service are provided by parking courts centrally located within each cluster. A proposed system of pedestrian walks, also suitable for light multipurpose maintenance vehicles will provide a network of access routes to the rear of nearly all buildings. In most cases, service entrances to ground floor dwellings are oriented to the rear of buildings.

Site Planners initially established the following program objectives preceding the evolution of this design:

1. Develop maximum linkage to existing environment.
2. Develop maximum interface compatibility.
3. Encourage joint (public/private) development.
4. Minimize intra-site vehicular/residential friction.
5. Develop a rational and comprehendible circulation and land use system.
6. Make optimum use of existing land.
7. Develop a rational and comprehendible open space system.

8. Maximize use of existing topography.
9. Maximize visual potential of Spring Valley Park.
10. Allow maximum use of diverse sub-systems.
11. Develop a structured vehicular and pedestrian circulation system which responds to the Breakthrough visitor requirements but minimizes disruption of normal residential activity patterns.
12. Allow maximum flexibility for housing systems developers.
13. Provide an equitable parceling system for housing systems developers.

14. Allow maximum use of housing types.

The initial planning studies, as prepared by Perkins and Will, Architects, Chicago, Illinois, together with the Site Plan (dated 15 October 1970), are the principal bases for this study of solid waste systems for this project.

Estimated Quantities and Types of Wastes to be Handled: Based upon an estimated resident population of 756 and a nominal waste production factor of 4 lbs per capita per day, it is expected that average daily waste production will be approximately 3,000 lbs. Distribution of this waste material by type and source of generation is estimated as follows:

Type of Waste	Garbage	Rubbish	Trash	Total
Daily Per Capita Production (lbs)	0.5	3.0	0.5	4.0
Total Daily Production (lbs)	378	2,268	378	3,024
Distribution of Total Daily Production:				
Dwelling Units (lbs)	378	2,040	-	2,418
Ancillary Areas (lbs)	-	114	-	114

Outdoor Common Areas (lbs)	-	114	378	492

It is anticipated that about 11 lbs of wastes will be generated within the average dwelling unit (average 3.4 persons) each day, and will consist of approximately 1.7 lbs of garbage, with the balance of about 9.3 lbs of mixed wastes for separate storage, collection, and disposal.

Available Municipal Services: The city provides no collection. It is all done by private contractors who have a highly organized association. Most of the private companies serve only residences with standard containers but bulk and commercial service is also available.

A typical charge is $2.85 per residence per month for collection service every third working day (about 1-1/2 times per week). Garbage must be wrapped and only one 20 gallon can is collected.

Selection of Candidate Systems: Basic systems that are compatible with the various types of dwelling units, other physical characteristics of this proposed development and the general program objectives of Operation Breakthrough are limited to the following:

18	Low-rise single family detached	Systems No. 1, 2, and 9
108	Low-rise single family attached	Systems No. 1, 2, 3, and 9
94	Low-rise multifamily	Systems No. 1, 2, 3, and 9

System No. 1 (garbage grinders) is desirable for installation in all dwelling units. Allowing an installed unit cost of $125, a total capital investment of about $27,500 will be required for the 220 dwellings in this project. With a life expectancy of 10 years and including maintenance, repairs, and operating costs, a total annual cost of about $22 is expected to be incurred by the occupants of each dwelling unit.

System No. 2 (variations of conventional collection system) may be considered for all (220) low-rise dwelling units. These variations are identified as follows:

System 2a--The conventional residential collection, consisting of curbside collection with a conventional packer truck, although in conflict with program objectives, is considered for economic comparison. This system, requiring no capital investment on the part of the developer, would cost the dwelling unit owner or occupant about $34 annually for service and an additional cost of about $12 annually for containers and accessories.

System 2b--House-to-house collection service weekly, using either a satellite collection vehicle or multipurpose maintenance vehicle for transfer of collected waste materials to intermediate storage locations may be considered as an alternate to the above. Costs of this system are proportionate to the dwelling unit costs as determined in the Macon study.

It is estimated that capital investment in equipment will be about $5,000, resulting in an equivalent annual capital cost of about $1,180 in addition to an estimated expense of $1,500 annually in equipment operation, maintenance, and repairs. It is also estimated that labor costs will approach $3,640 annually for the collector-operator. Collectively, costs of this internal system are expected to approach $6,320 annually or about $28 per dwelling unit, in addition to estimated minimum costs of $24 per dwelling unit for haul and disposal and $12 for containers and accessories.

System 2c--Occupants of low-rise single family attached and multifamily units are required to deposit accumulated wastes in bins centrally located in clusters. Multipurpose utility vehicles provide collection to detached waste and will tow these bins to intermediate storage locations. This transfer would be handled by management's general maintenance service. Costs of this service are proportionate to the dwelling unit costs as determined in the Macon study. It is estimated that such service could be provided for an annual cost of about $3,260 or $15 per dwelling unit, in addition to an estimated minimum cost of $24 per dwelling unit for haul and disposal and $12 for containers and accessories.

System No. 3 (console compactor stations) is considered for use in the clustered low-rise single family attached and low-rise multifamily units. The occupants are required to deposit accumulated wastes in the hoppers of these compactors and actuate the compaction cycle. Management's maintenance personnel would be required to service these units twice daily or as required. A minimum collection frequency of once weekly would be required. Based on the conceptual site plan, it is estimated that about 14 stations could be situated within the complex clusters to provide reasonably convenient access to these 202 dwelling units or an average of about 14 dwellings per compactor station. Initial capital investment of installed equipment is estimated at about $2,000 per station or $28,000. With a life expectancy of about 10 years, an equivalent annual capital expense of about $3,800 will be incurred. Materials, supplies, and other operating costs of this equipment are estimated at $2 per day per station or about $10,220 per year. Labor costs for servicing this equipment by management personnel are estimated at $10.50 (3 hrs at $3.50) daily (7-day basis) or $3,830 per year. Collectively, the annual costs of this system are estimated at $17,850 or about $88 per dwelling unit in addition to an estimated minimum cost of $18 per dwelling unit for haul and disposal and $12 for containers and accessories in the dwelling unit.

System No. 9 considers the use of under-counter compactors in all (220) low-rise dwelling units. Allowing an installed unit cost of $190, a total capital investment of about $41,800 will be required. With an estimated life expectancy of about 10 years, an equivalent annual capital expense of about $26 per dwelling unit will be incurred. Materials, supplies, and other operating costs to be incurred directly by the dwelling unit occupants will approach $33 per year per unit or a total of $7,260. Occupants of clustered units would be required to deposit packaged wastes in intermediate storage points within each cluster. With this system collection of this packaged material could be made once weekly with a satellite collection vehicle or multipurpose maintenance equipment, with transfer to intermediate storage locations. Estimated cost of this internal collection service would be comparable to those costs in System 2c or about $3,260 or $15 per dwelling unit per year. Collectively, the annual costs of this system are estimated at about $74 per dwelling unit in addition to an estimated minimum cost of $18 per dwelling unit for haul and disposal.

Evaluation of Candidate Systems: The evaluation of these candidate systems involved both the comparison of systems characteristics and economics of the respective systems installations.

The evaluation of system characteristics (Table 5) provides a deficiency rating of all pertinent characteristics in the sub-systems and the total deficiency rating of each system. Comparisons of these individual ratings between systems provide guidelines for the selection of the system(s) which may be more desirable for the respective types of dwelling units in the project. This method of ranking indicates that Systems No. 1 and 9 should be considered for all dwelling units.

The economic summary (Table 13) of these candidate systems illustrates the comparison of initial capital costs and total annual costs of each as well as equivalent dwelling unit costs for the respective types of dwellings.

Relating system costs and deficiency ratings to the program objectives indicate a combination of Systems No. 1 and 9 are the most suitable selections for the project, requiring an initial capital investment of about $74,050 with total annual costs of $25,040 or about $114 per year or $9.50 per month per dwelling unit.

TABLE 13

ECONOMIC EVALUATION OF SOLID WASTE SYSTEM ALTERNATIVES - KALAMAZOO, MICHIGAN

System No.	Dwelling Units		Capital Cost	Annual Operating Cost				Amortization of Capital Investment	Total Annual Cost	
	Type	No.		Labor	Other Operating Costs	Municipal or Contract Costs	Total		Project	Per DU
*1	All DU's	220	$27,500	-	$ 1,100	-	$ 1,100	$ 3,740	$ 4,840	$ 22
2a	All DU's	220	-	-	2,640	$ 7,480	10,120	-	10,120	46
2b	All DU's	220	5,000	$3,640	4,140	5,280	13,060	1,180	14,240	64
2c	All DU's	220	4,750	1,820	3,360	5,280	10,460	720	11,180	51
3	LR SFA MF	202	28,000	3,830	12,644	3,636	20,110	3,800	24,126	118
*9	All DU's	220	46,550	1,820	7,980	3,960	13,760	6,440	20,200	92
* Combination of Recommended Systems										
1 & 9		220	$74,050	$2,500	$ 9,080	$ 3,960	$14,860	$10,180	$25,040	$114

Jersey City, New Jersey

This Operation Breakthrough development is a part of a large urban renewal project. This housing development will be situated on an elongated irregular shaped parcel of 6.3 acres, with a frontage of about 1,000 ft on Newark Avenue, the south boundary, and a depth varying from about 160 to 360 ft. Summit Avenue borders the site on the east and Kennedy Boulevard on the west.

The site will contain 500 dwelling units, including 3 low-rise, 4 medium-rise, and 4 high-rise structures ranging from three to twenty-four stories in height above two levels of parking and service areas. A 3-story structure at the northwestern corner of the site above the two service levels will contain about 50,000 square feet of commercial and office space. Vehicular access to parking and service levels is provided from the south and east boundary streets. Proposed areas for a preschool center of 5,000 square feet, a public school of about 20,000 square feet, and community recreational facilities are centrally located within the development.

The initial planning study, as prepared by David A. Crane and Associates, Philadelphia, Pennsylvania, together with the Preliminary Site Plan (dated 11 August 1970), are the principal bases for this study of solid waste systems for this project.

Estimated Quantities and Types of Wastes to be Handled: Based upon an estimated resident population of 1,640 and a nominal waste production factor of 4 lbs per capita per day, it is expected that average daily waste production will be about 6,560 lbs. Additional generation of waste should be anticipated in the school plant and commercial building. Although these facilities are not fully defined, a waste production allowance of approximately 500 lbs for the school and 2,500 lbs for the commercial building should be adequate. Distribution of this waste material by type and source of generation is estimated as follows:

Type of Waste	Garbage	Rubbish	Trash	Total
Daily Per Capita Production (lbs)	0.5	3.0	0.5	4.0
Daily Resident Production (lbs)	820	4,920	820	6,560
Other Production (lbs)	1,000	2,000	-	3,000
Distribution of Total Daily Production:				
Dwelling Units (lbs)	820	4,430	-	5,250
Ancillary Areas (lbs)	-	245	-	245

Outdoor Common Areas (lbs)	-	245	820	1,065
School Plant (lbs)	-	500	-	500
Commercial Building (lbs)	1,000	1,500	-	2,500

It is anticipated that about 10.5 lbs of wastes will be generated within the average dwelling unit (average 3.3 persons) each day and will consist of approximately 1.6 lbs of garbage, with the balance of about 8.9 lbs of mixed wastes for separate storage, collection, and disposal.

Available Municipal Services: Solid waste collection and disposal are controlled by the Jersey City Incinerator Commission which contracts with private firms for both collection service and incinerator operation.

The collection contractor, headquartered in Paramus, New Jersey, provides twice a week collection from residences only at no direct charge. The waste must be placed at the curbside in cans or bags of no greater than 100 pounds in weight. They service no bulk containers but have made arrangements for a 1,500 townhouse development to collect bagged waste from a central storage point, with onsite collection provided by the developer.

For the Operation Breakthrough site, where assembly of individual cans or bags is impractical, it may be necessary to contract for bulk container service unless special arrangements can be made with the city's contractor. Based upon gross annual waste production of 20,440 cubic yards or 1,740 tons at this complex, an equivalent annual production of 41 cubic yards or 3.5 tons per dwelling unit has been calculated. A minimum allowance of $18 per dwelling unit per year (which is equivalent to $0.43 per cubic yard or $5.15 per ton bulk rate) for haul and disposal has been adopted for purposes of this study. Collection of bulky items from a central storage point would be provided by the city on a call basis at no fee.

Selection of Candidate Systems: Basic systems that are compatible with the various types of dwelling units, other physical characteristics of this proposed development and the general program objectives of Operation Breakthrough are limited to Systems No. 1, 4, and 6. However local authorities will not permit use of garbage grinders (System No. 1) at this location.

System No. 4 considers the use of 12 separate chute-fed stationary baler or compactor installations for this complex. Initial capital investment for equipment for the installations is expected to approach $84,000. With a life expectancy of about 10 years, an equivalent annual capital expense of about $11,400 will be incurred. Materials, supplies, and other operating costs are estimated to average about $2 per day per station or about $8,760 per year. Labor costs for servicing this equipment by management's personnel are estimated at $30 (8 hrs at $3.50) daily (7-day basis) or $10,950 per year. Collectively, the annual costs of this system are estimated at $31,110 for the 500 dwelling units, or about $62 per dwelling unit, in addition to an estimated minimum cost of $18 per dwelling unit for haul and disposal and $12 for containers and accessories in the dwelling units.

System No. 6 considers the use of a pneumatic waste collection system serving all dwelling units in this project. The collector conduit or pipeline will interface with gravity chutes, in all structures. As in the case of System No. 4, it is estimated that approximately 12 chutes' would be required. Wastes will be transported to a centrally located compactor station for processing and storage. Based on preliminary estimates, the pneumatic system is expected to cost about $450,000. With a life expectancy of about 50 years, the equivalent annual capital expense will be about $28,600. The cost of the central compactor station is expected to approach $20,000 and with a life expectancy of 10 years, the equivalent annual capital expense will be about $2,720.

Manufacturers of the pneumatic system estimate that annual maintenance repairs and other operating costs will be equivalent to about 1 percent of the installed cost or $4,700. Collectively, the annual costs of this system are estimated at $36,020 or about $72 per dwelling unit, in addition to the estimated minimum cost of $18 per dwelling unit for haul and disposal and $12 for containers and accessories in the dwelling unit.

Evaluation of Candidate Systems: The evaluation of these candidate systems involved both the comparison of systems characteristics and economics of the respective systems installations.

The evaluation of system characteristics (Table 5) provides a deficiency rating of all pertinent characteristics in the sub-systems and the total deficiency rating of each system. Comparisons of these individual ratings between systems provide guidelines for the selection of the system which may be more desirable for the respective types of dwelling units in the project.

The economic summary (Table 14) of these candidate systems illustrates the comparison of initial capital costs and total annual costs of each as well as equivalent dwelling unit costs for the respective types of dwellings.

Relating system costs and deficiency ratings to the program objectives indicate that System No. 1 would offer the highest level of service in the inter-unit and inter-building systems benefiting the project ar large. Although it is estimated that a large capital investment ($470,000) would be required, the total costs of $102 per dwelling unit per year or $8.00 per month would be slightly higher than the alternative system.

TABLE 14

ECONOMIC EVALUATION OF SOLID WASTE SYSTEM ALTERNATIVES - JERSEY CITY, NEW JERSEY

System No.	Dwelling Units		Capital Cost	Annual Operating Cost				Amortization of Capital Investment	Total Annual Cost (1)	
	Type	No.		Labor	Other Operating Costs	Municipal or Contract Costs	Total		Project	Per DU
4	All DU's	500	$ 84,000	$10,950	$14,760	$ 9,000	$34,710	$11,400	$46,110	$ 92
*6	All DU's	500	470,000	-	10,700	9,000	19,700	31,320	$51,020	102

* The Recommended System

(1) Total annual costs include cost of handling commercial and other ancillary facility wastes

Sacramento, California

The Sacramento housing development, to be situated on a 32-acre square shaped parcel, will contain 407 dwelling units, including 20 single family detached, 181 single family attached, 96 low-rise multifamily, and 110 high-rise multifamily units. The site is bounded on the south by an existing public street (Broadway). Proposed access streets to the site will be located on the east and west boundaries. A connecting street between these boundary streets will bisect the site at the northerly quarter.

All single family detached units and 25 single family attached units will be located in the northerly quarter of the site, grouped into four clusters, with vehicular access from the connecting road into cul de sacs serving each cluster. The balance of single family attached units and low-rise multifamily units are generally grouped in clusters around the perimeter of the remaining parcel. These clusters are separated and oriented to ten elongated parking courts with vehicular access from the perimeter streets.

The inner area (approximately five acres) of this remaining parcel is reserved as open recreational space, with a community center and high-rise apartment building situated immediately to the south. Parking for these facilities is provided by two of the previously mentioned parking courts. A vehicular service drive is extended from one of the parking courts to the high-rise structure.

The initial planning study, as prepared by Wurster, Bernardi and Emmons, Inc., Prototype Site Planners, San Francisco, California, together with the Master Site Plan (dated 19 October 1970) are the principal bases for this study of solid waste systems for this project.

The planning study set forth the following project objectives preceding design:

1. To provide living densities which will reduce per unit land and site development costs.
2. To provide for methods of service and site facility design, construction, and operation that can reduce site development and operating costs and improve the living environment.
3. To create a physical and social pattern that will be harmonious with the surrounding community and in the case of presently undeveloped surrounding community, the pattern should not unduly restrict development.
4. To make maximum use of the natural features.
5. To plan for housing (rental and owner occupied) with varied family sizes, income levels, and sponsorship methods to assure a socioeconomic tenant mix.

6. To provide visitor facilities adaptable for community usage after prototype review and evaluation.

7. To assure proper consideration is granted to wishes of the surrounding community and prospective occupants of the site.

8. To provide an environment superior to, yet compatible with the surrounding community.

9. To develop the project on a scale compatible with the surrounding neighborhood.

10. To search out potential linkages and relationships which exist in the surrounding community.

11. To suggest innovative concepts in site design.

12. To suggest additional community facilities which will assist in unifying the project and the surrounding community.

13. To develop a system of unit locations which will maximize assets of each unit while minimizing differences in scale, color, texture, and form.

The following is a list of possible alternatives considered by the Site Planner at the primary design focus:

1. Develop the project as a cohesive community fitting comfortably into the surrounding neighborhood and containing a racial mix and an economic mix to the extent to which this income mix can be

accommodated on a small site. This focus would be designed to create a mass-produced housing community specifically oriented to avoid the stigma associated with public housing and to achieve maximum developer and consumer acceptance.

2. Develop the project to demonstrate the maximum number of innovations including new financing techniques. Such an approach would require absolute cooperation between the Prototype Site Planner and the Housing Systems Manufacturers.

3. Develop the project as a complex to serve for a period of time, say two years, as a supermarket of mass-produced housing types where prospective buyers, including individual residential unit owners and developers, could look at the different building systems and select the one they wish to develop or purchase at other locations.

Estimated Quantities and Types of Wastes to be Handled: Based upon an estimated resident population of 1,585 and a nominal waste production factor of 4 lbs per capita per day, it is expected that average daily waste production will be about 6,300 lbs. Distribution of this waste material by type and source of generation is estimated as follows:

Type of Waste	Garbage	Rubbish	Trash	Total
Daily Per Capita Production (lbs)	0.5	3.0	0.5	4.0

Total Daily Production (lbs)	792	4,755	793	6,340
Distribution of Total Daily Production:				
Dwelling Units (lbs)	792	4,275	-	5,067
Ancillary Areas (lbs)	-	240	-	240
Outdoor Common Areas (lbs)	-	240	793	1,033

It is anticipated that about 12.5 lbs of wastes will be generated within the average dwelling unit (average 3.9 persons) each day and will consist of about 2 lbs of garbage with a balance of about 10.5 lbs of mixed wastes for separate storage, collection, and disposal.

Available Municipal Services: A variety of service is available from the city and direct charges are made on the utility bill. The following rates are charged:

$1.65 per dwelling per month for once a week collection of one can.

$2.65 per dwelling per month for once a week collection of two cans.

$3.65 per dwelling per month for twice a week collection of one can.

Selection of Candidate Systems: Basic systems that are compatible with the physical characteristics of this proposed development and the general program objectives of Operation Breakthrough are limited to the following:

20 Low-rise single family detached	Systems No. 1, 2, and 9
181 Low-rise single family attached	Systems No. 1, 2, 3, and 9
96 Low-rise multifamily	Systems No. 1, 2, 3, and 9
110 High-rise multifamily	Systems No. 1 and 4

System No. 1 (garbage grinders) is desirable for installation in all dwelling units. Allowing an installed unit cost of $125, a total capital investment of about $50,875 will be required for the 407 dwelling units in this project. With a life expectancy of ten years and including maintenance, repairs, and operating costs, a total annual cost of about $22 is expected to be incurred by the occupants of each dwelling unit.

System No. 2 (variations of conventional collection system) may be considered for all (297) low-rise dwelling units. These variations are identified as follows:

System 2a--The conventional municipal collection, consisting of house-to-house collection with a conventional packer truck, although in minor conflict with program objectives, is considered for economic comparison. This system, requiring no capital investment on the part of the developer, will cost the dwelling unit owner or occupant about $34 annually for municipal service and an additional cost of about $12 for containers and accessories.

System 2b--House-to-house collection service weekly, using either a satellite collection vehicle or multipurpose maintenance vehicle for transfer of collected waste materials to intermediate storage locations may be considered as an alternate to the above. Costs are proportionate to the annual dwelling unit costs as determined in the Macon study. It is estimated that capital investment in equipment will be about $6,625 with an equivalent annual capital cost of about $1,540 in addition to an estimated expense of $1,965 annually in equipment operation, maintenance, and repairs. It is also estimated that labor costs will approach $4,760 (1,360 hrs at $3.50 per hour) annually for the collector-operators. Collectively, costs of ths internal system are expected to approach $8,265 annually or about $28 per dwelling unit, in addition to estimated minimum costs of $24 per dwelling unit for haul and disposal and $12 for containers and accessories.

System 2c--Occupants are required to deposit accumulated wastes in bins centrally located in clusters. Multipurpose utility vehicles will provide collection service to single family detached and two these bins to intermediate storage locations. This transfer would be handled by management's general maintenance service. The following costs are proportionate to annual dwelling unit costs as determined in the Macon study. It is estimated that such service could be provided for an annual cost of about $4,260 or under $15 per dwelling unit, in addition to the estimated minimum cost of $24 per dwelling unit for haul and disposal and $12 for containers and accessories.

System No. 3 (console compactor stations) is considered for use in the clustered low-rise single family attached and low-rise multifamily units. The occupants are required to deposit accumulated wastes in the hoppers of these compactors and actuate the compaction cycle. Management's maintenance personnel would be required to service these units twice daily or as required. A minimum collection frequency of once weekly would be required. Based on the conceptual site plan, it is estimated that about 14 stations could be situated within the complex clusters to provide reasonably convenient access to these 277 dwelling units or an average of about 20 dwellings per compactor station. Initial capital investment of installed equipment is estimated at about $2,000 per station or $28,000. With a life expectancy of about 10 years, an equivalent annual capital expense of about $3,410 will be incurred. Materials, supplies, and other operating costs of this equipment are estimated at $2 per day per station or about $10,220 per year. Labor costs for servicing this equipment by management personnel are estimated at $14 (4 hrs at $3.50) daily or $5,100 per year. Collectively, the annual costs of this system are estimated at $18,730 or about $60 per dwelling unit in addition to an estimated minimum cost of $18 per dwelling unit for haul and disposal and $12 for containers and accessories in the dwelling unit.

System No. 4 considers the use of a separate chute-fed stationary baler installation in the high-rise building. Initial capital investment for equipment for the installation is expected to approach $7,000. With a life expectancy of about 10 years, an equivalent annual capital expense of about $955 will be incurred. Materials, supplies, and other operating costs are estimated to average about $3 per day or about $1,095 per year. Labor costs for servicing this equipment by management personnel are estimated at $7 (2 hrs at $3.50) daily or $2,555 per year. Collectively, the annual costs of this system are estimated at $4,605 for the 110 dwelling units, or about $42 per dwelling unit, in addition to an estimated minimum cost of $18 per dwelling unit for haul and disposal and $12 for containers and accessories.

System No. 9 considers the use of under-counter compactors in all (297) low-rise dwelling units. Allowing an installed unit cost of $190, a total capital investment of about $56,430 will be required. With an estimated life expectancy of about 10 years, an equivalent annual capital expense of about $26 per dwelling unit will be incurred. Materials, supplies, and other operating costs to be incurred directly by the dwelling unit occupants will approach $33 per year per unit or a total of $9,801. Occupants of clustered units would be required to deposit packaged wastes in intermediate storage points within each cluster. With this system, collection of this packaged material could be made once weekly with a satellite collection vehicle or multipurpose maintenance equipment, with transfer to intermediate storage locations. Estimated cost of this internal collection service would be comparable to those costs in System 2c or about $4,260 or under $15 per dwelling unit per year. Collectively, the annual costs of this system are estimated at about $73 per dwelling unit in addition to an estimated minimum cost of $18 per dwelling unit for haul and disposal.

Evaluation of Candidate Systems: The evaluation of these candidate systems involved both the comparison of systems characteristics and economics of the respective systems installations.

The evaluation of system characteristics (Table 5) provides a deficiency rating of all pertinent characteristics in the sub-systems and the total deficiency rating of each system. Comparisons of these individual ratings between systems provide guidelines for the selection of the system(s) which may be more desirable for the respective types of dwelling units in the project. This method of ranking indicates that System No. 1 should be considered for all dwelling units and supplemented by System No. 9 in the low-rise structures and System No. 4 in the high-rise structure.

The economic summary (Table 15) of these candidate systems illustrates the comparison of initial capital costs and total annual costs of each as well as equivalent dwelling unit costs for the respective types of dwellings.

Relating system costs and deficiency ratings to the program objectives indicate a combination of Systems No. 1, 4, and 9 are the most suitable selections for the project, requiring an initial capital investment of about $120,535 with total annual costs of $43,988 or about $108 per year or $9.00 per month per dwelling unit.

TABLE 15

ECONOMIC EVALUATION OF SOLID WASTE SYSTEM ALTERNATIVES - SACRAMENTO, CALIFORNIA

System No.	Dwelling Units		Capital Cost	Annual Operating Cost				Amortization of Capital Investment	Total Annual Cost	
	Type	No.		Labor	Other Operating Costs	Municipal or Contract Costs	Total		Project	Per DU
*1	All DU's	407	$ 50,875	-	$ 2,035	-	$ 2,035	$ 6,919	$ 8,954	$ 22
2a	All LR	297	-	-	3,564	$10,098	13,662	-	13,662	46
2b	All LR	297	6,625	$4,760	5,529	7,128	17,417	1,540	18,957	64
2c	All LR	297	6,225	2,380	4,504	7,128	14,012	940	14,952	51
3	LR SFA MF	277	28,000	5,100	13,544	4,986	23,630	3,410		98
*4	HR	110	7,000	2,555	2,415	1,980	6,950	955	7,905	72
*9	All LR	297	62,660	2,380	10,741	5,346	18,467	8,662	27,129	91
* Combination of Recommended Systems										
1, 4, 9		407	$120,535	$4,935	$15,291	$ 7,326	$27,452	$16,536	$43,988	$108

Seattle, Washington

The Seattle housing development is expected to be situated on a 1.7-acre square-shaped parcel and will contain approximately 60 multifamily dwelling units in low-rise and medium-rise structures. The proposed site is bounded on the north by Yeasler Street and on the west by 18th Avenue. Adjacent property to the south and east are reserved as open space and future ancillary facilities, not fully defined at the present time. This property extends east to 20th Avenue and south to Main Street.

A medium-rise building of about five stories will be situated on the north boundary. Low-rise buildings of three stories will be situated on the west and south boundaries of the housing site.

The principal public entrance to the housing complex will be located at the northwesterly corner of the site joining the medium-rise and one of the low-rise buildings. Common stairs as well as elevator service will be located in this lobby area. All buildings will be on grade. Basements will not be provided in this complex. All ground floor apartments will have private patios with service oriented to the inner court. The inner court formed by these structures will contain surface parking and open space. Vehicular access to the parking court will be provided from 18th Avenue.

The initial planning study and supplemental reports, as prepared by Building Systems Development, San Francisco, California, together with the Site Plan (dated 9 October 1970) are the principal bases for this study on solid waste systems for this project.

Estimated Quantities and Types of Wastes to be Handled: Based upon an estimated resident population of 285 and a nominal waste production factor of 4 lbs per capita per day, it is expected that average daily waste production will be about 1,140 lbs. Distribution of this waste material by type and source of generation is estimated as follows:

Type of Waste	Garbage	Rubbish	Trash	Total
Daily Per Capita Production (lbs)	0.5	3.0	0.5	4.0
Total Daily Production (lbs)	142	855	143	1,140
Distribution of Total Daily Production:				
Dwelling Units (lbs)	142	770	-	912
Ancillary Areas (lbs)	-	42	-	42

Outdoor Common Areas (lbs)	-	43	143	186

It is anticipated that about 15.2 lbs of wastes will be generated within the average dwelling unit (average 4.8 persons) each day and will consist of about 2.4 lbs of garbage with a balance of about 12.8 lbs of mixed wastes for separate storage, collection, and disposal.

Available Municipal Services: The city provides no collection but operates a transfer station and disposal site. Collection is provided by private collectors on contract to the city. The city charges residents $2.70 per dwelling unit per month for the combined collection and disposal service.

Selection of Candidate Systems: Basic systems that are compatible with the various types of dwelling units, other physical characteristics of this proposed development and the general program objectives of Operation Breakthrough are limited to the following:

37 Low-rise multifamily	Systems No. 1, 2, 3, and 9
23 Medium-rise multifamily	Systems No. 1, 3, and 4

System No. 1 (garbage grinders) is desirable for installation in all dwelling units. Allowing an installed unit cost of $125, a total capital investment of about $7,500 will be required for the 60 dwelling units in this project. With a life expectancy of ten years and including maintenance, repairs, and operating costs, a total annual cost of about $22 is expected to be incurred by the occupants of each dwelling unit.

System No. 2 (variations of conventional collection system) may be considered for the (37) low-rise dwelling units. These variations are identified as follows:

System 2a--The conventional municipal collection, although in minor conflict with program objectives, is considered for economic comparison. This system, requiring no capital investment on the part of the developer, will cost the dwelling unit owner or occupant about $32 annually for service and an additional cost of about $12 annually for containers and accessories.

System 2b--Due to the relatively small size and configuration of this project, house-to-house collection vehicle or multipurpose maintenance vehicle for transfer of collected waste materials to intermediate storage locations, does not appear feasible.

System 2c--Occupants are required to deposit accumulated wastes in bins centrally located to the low-rise units. Multipurpose utility vehicles will move these bins a short distance to an intermediate storage location. This transfer would be handled by management's general maintenance service at minimum cost. Annual costs for this service (proportionate to the dwelling unit costs as determined in the Macon study) are estimated at $538 or about $15 per dwelling unit in addition to an estimated minimum cost of $24 for haul and disposal and $12 for containers and accessories.

System No. 3 (console compactor stations) is considered for use in the low-rise and medium-rise multifamily units. The occupants are required to deposit accumulated wastes in the hoppers of these compactors and actuate the compaction cycle. Management's maintenance personnel would be required to service these units daily. A minimum collection frequency of once weekly would be required. Based on the conceptual site plan, it is estimated that about 3 stations could be situated within the complex to provide reasonably convenient access to these 60 dwelling units or an average of about 20 dwellings per compactor station. Initial capital investment of installed equipment is estimated at about $2,000 per station or $6,000. With a life expectancy of about 10 years, an equivalent annual capital expense of about $820 will be incurred. Materials, supplies, and other operating costs of this equipment are estimated at $2 per day per station or about $2,190 per year. Labor costs for servicing this equipment by management's personnel are estimated at $3.50 (1 hr at $3.50) daily (7-day basis) or $1,277 per year. Collectively, the annual costs of this system are estimated at $4,287 or about $71 per dwelling unit in addition to an estimated minimum cost of $18 for haul and disposal and $12 for containers and accessories in the dwelling unit.

System No. 4 considers the use of a chute-fed stationary baler installation in the medium-rise building. Initial capital investment for equipment for the installation is expected to approach $4,000. With a life expectancy of about 10 years, an equivalent annual capital expense of about $544 will be incurred. Materials, supplies, and other operating costs are estimated to average about $2 per day or about $730 per year. Labor costs for servicing this equipment by management's personnel are estimated at $1.75 (1/2 hr at $3.50) daily (7-day basis) or $638 per year. Collectively, the annual costs of this system are estimated at $1,912 for the 23 dwelling units, or about $83 per dwelling unit, in addition to the estimated minimum cost of $18 for haul and disposal and $12 for containers and accessories.

System No. 9 considers the use of under-counter compactors in all (37) low-rise dwelling units. Allowing an installed unit cost of $190, a total capital investment of about $7,030 will be required. With an estimated life expectancy of about 10 years, an equivalent annual capital expense of about $26 per dwelling unit will be incurred. Materials, supplies, and other operating costs to be incurred directly by the dwelling unit occupants will approach $33 per year per unit or a total of $1,221. Occupants of these units would be required to deposit packaged wastes in intermediate storage bins. With this system transfer of these bins could be made once weekly to a central loading station at minimal cost. Estimated cost of this internal collection service would be comparable to the costs of System 2c or about $538 or $15 per dwelling unit per year. Collectively, the annual costs of this system are estimated at about $74 per dwelling unit in addition to an estimated minimum cost of $18 for haul and disposal.

Evaluation of Candidate Systems: The evaluation of these candidate systems involved both the comparison of systems characteristics and economics of the respective systems installations.

The evaluation of system characteristics (Table 5) provides a deficiency rating of all pertinent characteristics in the sub-systems and the total deficiency rating of each system. Comparisons of these individual ratings between systems provide guidelines for the selection of the system(s) which may be more desirable for the respective types of dwelling units in the project. This method of ranking indicates that System No. 1 should be considered for all dwelling units and supplemented by System No. 9 in the low-rise structures and System No. 4 in the medium- and high-rise structures.

The economic summary (Table 16) of these candidate systems illustrates the comparison of initial capital costs and total annual costs of each as well as equivalent dwelling unit costs for the respective types of dwellings.

Relating system costs and deficiency ratings to the program objectives indicate a combination of Systems No. 1, 4, and 9 are suitable selections for the project, requiring an initial capital investment of about $19,300 with total annual costs of $7,309 or about $122 per dwelling unit or $10.20 per month. Economically, the combination of Systems No. 1 and 3 are competitive and consideration is warranted.

TABLE 16

ECONOMIC EVALUATION OF SOLID WASTE SYSTEM ALTERNATIVES - SEATTLE, WASHINGTON

System No.	Dwelling Units		Capital Cost	Annual Operating Cost				Amortization of Capital Investment	Total Annual Cost	
	Type	No.		Labor	Other Operating Costs	Municipal or Contract Costs	Total		Project	Per Du
*1	All Du's	60	$ 7,500	-	$ 300	-	$ 300	$1,020	$1,320	$ 22
2a	All LR	37	-	-	444	$1,184	1,628	-	1,628	44
2c	All LR	37	770	$ 308	559	888	1,755	115	1,870	51
*3	All Du's	60	6,000	1,277	2,910	1,080	5,267	820	6,087	101
*4	MR	23	4,000	638	1,006	414	2,058	544	2,602	113
*9	All LR	37	7,800	308	1,336	666	2,310	1,077	3,387	92
*Combination of Recommended Systems										
1 & 3		60	$13,500	$1,277	$3,210	$1,080	$5,567	$1,840	$7,407	123
1,4 & 9		60	19,300	946	2,636	1,080	4,668	2,641	7,309	122

King County, Washington

This Operation Breakthrough development,to be situated on a 30-acre parcel, will contain 162 dwelling units, including 58 single family detached, 80 single family attached, and 24 low-rise multifamily units. Vehicular access to the housing development is limited to single access streets from the east (N.E. 149th Street) and west (N.E. 148th Street), which connect to an inner loop road (Circle Drive). The single family detached units are grouped in nine major clusters in the westerly portion of the site. Vehicular access and service to these clusters is by a system of cul de sacs and common drives. The balance of structures is contained in seven major clusters served by off street parking courts. In five of these clusters (containing 62 dwelling units), service areas are located in private rear patios remotely oriented from streets and parking areas. In the remaining two clusters (containing 32 single family attached units), service areas are located in private rear patios remotely oriented from streets and parking areas. In the remaining two clusters (containing 32 single family attached units) service access is oriented to parking courts where maneuverability of large service vehicles would be limited as well as undesirable.

The inner portion of the parcel, bounded by the loop road, will be maintained as open park area. A community center, fronting on the loop road, will adjoin this park area. A network of pedestrian ways interconnects the clusters of dwelling units to the community center in this parcel.

The initial planning study, as prepared by Dean, Eckbo, Austin, and Williams, Landscape Architects and Planners, San Francisco, California, and Site Plan (dated 8 October 1970) are the principal bases for this study of solid waste systems for this project.

Estimated Quantities and Types of Wastes to be Handled: Based upon an estimated resident population of 900 and a nominal waste production factor of 4 lbs per capita per day, it is expected that average daily waste production will approach 3,600 lbs. Distribution of this waste material by type and source of generation is as follows:

Type of Waste	Garbage	Rubbish	Trash	Total
Daily Per Capita Production (lbs)	0.5	3.0	0.5	4.0
Total Daily Production (lbs)	450	2,700	450	3,600
Distribution of Total Daily Production:				
Dwelling Units (lbs)	450	2,430	-	2,880

Ancillary Areas (lbs)	-	135	-	135
Outdoor Common Areas (lbs)	-	135	450	585

It is anticipated that about 17.8 lbs of wastes will be generated within the average dwelling unit (average 5.5 persons) each day and will consist of approximately 2.8 lbs of garbage with a balance of about 15 lbs of mixed wastes for separate storage, collection, and disposal.

Available Municipal Services: Collection is provided by 22 private haulers who transport to a county-owned transfer station. Rates for collection are set by the Washington Utilities and Transportation Commission and average $2.70 per dwelling per month. The range is from $2.40 to $2.90. An additional charge of 30¢ per dwelling per month is made for backyard collection.

Selection of Candidate Systems: Basic systems that are compatible with the various types of dwelling units, other physical characteristics of this proposed development and the general program objectives of Operation Breakthrough are limited to the following:

58 Low-rise single family detached	Systems No. 1, 2, and 9
80 Low-rise single family attached	Systems No. 1, 2, 3, and 9
24 Low-rise multifamily	Systems No. 1, 2, 3, and 9

System No. 1 (garbage grinders) is desirable for installation in all dwelling units. Allowing an installed unit cost of $125, a total capital investment of about $20,250 will be required for the 162 dwelling units in this project. With a life expectancy of 10 years and including maintenance, repairs, and operating costs, a total annual cost of about $22 is expected to be incurred by the occupants of each dwelling unit.

System No. 2 (variations of conventional collection system) may be considered for all (162) low-rise dwelling units. These variations are identified as follows:

System 2a--The conventional municipal collection, consisting of curbside collection with a conventional packer truck, although in minor conflict with program objectives, is considered for economic comparison. This system, requiring no capital investment on the part of the developer, would cost the dwelling unit owner or occupant about $32 annually for service and an additional cost of about $12 annually for containers and accessories.

System 2b--House-to-house collection service weekly, using either a satellite collection vehicle or multipurpose maintenance vehicle for transfer of collected waste materials to intermediate storage locations may be considered as an alternate to the above. The following costs of this system are proportionate to dwelling unit costs as determined in the Macon study. It is estimated that capital investment in equipment will be about $3,660, resulting in an equivalent annual capital cost of about $845, in addition to an estimated expense of $1,666 annually in equipment operation, maintenance, and repairs. It is also estimated that labor costs will approach $2,600 annually for the collector-operator. Collectively, costs of this internal system are expected to approach $4,611 annually or about $28 per dwelling unit, in addition to an estimated mininum cost of $24 per dwelling unit for haul and disposal and $12 for containers and accessories.

System 2c--Occupants of the single family attached and multifamily units are required to deposit accumulated wastes in bins centrally located in clusters. Multipurpose utility vehicles will provide collection to the single family detached units and tow the bins to intermediate storage locations. This transfer would be handled by management's general maintenance service. Annual costs for this service (proportionate to the dwelling unit costs as determined in the Macon study) are estimated at about $2,330 or under $15 per dwelling unit, in addition to an estimated minimum cost of $24 per dwelling unit for haul and disposal and $12 for containers and accessories.

System No. 3 (console compactor stations) is considered for use in the clustered low-rise single family attached and low-rise multifamily units. The occupants are required to deposit accumulated wastes in the hoppers of these compactors and actuate the compaction cycle. Management's maintenance personnel would be required to service these units twice daily or as required. A minimum collection frequency of once weekly would be required. Based on the conceptual site plan, it is estimated that about 9 stations could be situated within the complex clusters to provide reasonably convenient access to these 104 dwelling units or an average of about 12 dwellings per compactor station. Initial capital investment of installed equipment is estimated at about $2,000 per station or $18,000. With a life expectancy of about 10 years, an equivalent annual capital expense of about $2,448 will be incurred. Materials, supplies, and other operating costs of this equipment are estimated at $2 per day per station or about $6,570 per year. Labor costs for servicing this equipment by management personnel are estimated at $7 (2 hrs at $3.50) daily or $2,555 per year. Collectively, the annual costs of this system are estimated at $11,573 or about $111 per dwelling unit in addition to an estimated minimum cost of $18 per dwelling unit for haul and disposal and $12 for containers and accessories in the dwelling unit.

System No. 9 considers the use of under-counter compactors in all (162) low-rise dwelling units. Allowing an installed unit cost of $190, a total capital investment of about $30,780 will be required. With an estimated life expectancy of about 10 years, an equivalent annual capital expense of about $26 per dwelling unit will be incurred. Materials, supplies, and other operating costs to be incurred directly by the dwelling unit occupants will approach $33 per year per unit or a total of $5,346. Occupants of clustered units would be required to deposit packaged wastes in intermediate storage points within each cluster. With this system collection of this packaged material could be made once weekly with a satellite collection vehicle or multipurpose maintenance equipment, with transfer to intermediate storage locations. Estimated cost of this internal collection service would be comparable to those costs in System 2c or about $2,330 or under $15 per dwelling unit per year. Collectively, the annual costs of this system are estimated at about $74 per dwelling unit in addition to the municipal cost of $18 for haul and disposal.

Evaluation of Candidate Systems: The evaluation of these candidate systems involved both the comparison of systems characteristics and economics of the respective systems installations.

The evaluation of system characteristics (Table 5) provides a deficiency rating of all pertinent characteristics in the sub-systems and the total deficiency rating of each system. Comparisons of these individual ratings between systems provide guidelines for the selection of the system(s) which may be more desirable for the respective types of dwelling units in the project. This method of ranking indicates that System No. 1 should be considered for all dwelling units and supplemented by System No. 9 in the low-rise structures and System No. 4 in the medium- and high-rise structures.

The economic summary (Table 17) of these candidate systems illustrates the comparison of initial capital costs and total annual costs of each as well as equivalent dwelling unit costs for the respective types of dwellings.

Relating system costs and deficiency ratings to the program objectives indicate a combination of Systems No. 1 and 9 are the most suitable selections for the project, requiring an initial capital investment of $54,430 with total annual costs of $18,368 or about $113 per dwelling unit per year or $9.45 per month.

TABLE 17

ECONOMIC EVALUATION OF SOLID WASTE SYSTEM ALTERNATIVES - KING COUNTY, WASHINGTON

System No.	Dwelling Units		Capital Cost	Annual Operating Cost				Amortization of Capital Investment	Total Annual Cost	
	Type	No.		Labor	Other Operating Costs	Municipal or Contract Costs	Total		Project	Per Du
*1	All Du's	162	$20,250	-	$ 810	-	$ 810	$2,754	$ 3,564	$ 22
2a	All Du's	162	-	-	1,944	$5,184	7,128	-	7,128	44
2b	All Du's	162	3,660	$2,600	3,110	3,888	9,598	845	10,445	64
2c	All Du's	162	3,400	1,300	2,459	3,888	7,647	515	8,162	51
3	SFA MF	104	18,000	2,555	7,818	1,872	12,245	2,448	14,693	141
*9	All Du's	162	34,180	1,300	5,861	2,916	10,077	4,727	14,804	92
*Combination of Recommended Systems										
1&9		162	$54,430	$1,300	$,6,671	$2,916	$10,887	$7,481	$18,368	$113

APPENDIX

RESEARCH PLAN FOR OPERATION BREAKTHROUGH DEMONSTRATION PROJECTS

Based upon the preceding studies of the Operation Breakthrough program and the need for research on improved solid waste systems, Memphis, Jersey City, and other sites were considered as locations for pilot projects. It is anticipated that continuing investigation of solid waste systems will be carried out at several selected locations in Phase II of this study.

Specified in the scope of this current study (Phase I) was the determination of the scope of the research program for those systems selected for continuing study. The plan should consider detailed requirements for laboratory and pilot scale tests and a suggested plan or guidelines to be followed during the design, construction, installation, and operational phases of the full scale systems.

Details of this concluding section of study are related to the broad requirements of each type of system considered in the proposed projects.

Among the systems considered and discussed herein, are those employing pneumatic conveyors and various types of compaction devices.

Pneumatic Waste Collection Systems

Pneumatic waste collection systems, coupled with stationary compactor stations for processing and storage requirements, have been recommended previously as the primary systems for both the Memphis and Jersey City projects and considered as warranted for continuing investigation. It was anticipated, due to the development schedules of these projects, that the award of the waste systems design contracts would be made in advance of the completion of this study (Phase I), and that overlapping of the continuing study (Phase II) will occur. Based upon this premise, the schedule of this section was accelerated with completion occurring in advance of certain portions of the preceding background material.

Design Procurement Specifications: Initial requirements were for the development of criteria for systems design procurement. The development of these would be intended for use at any location, not a specific site.

Earlier investigations of pneumatic systems established that there were only three which were marketed and adaptable to housing complex installations. Each of these systems varies in characteristics of materials and special equipment components used. However, all operate on basically the same principle.

After trial comparisons and evaluations of these systems, design procurement specifications were prepared that were broad enough for participation and compliance by the known manufacturers of these systems, and that provided a comprehensive basis for evaluation of design standards compatible with HUD's systems evaluation methods.

As this criteria was developed, basic design standards were identified, including broad parameters such as (1) space, illumination, and ventilation for the mechanical equipment center and valve rooms, (2) routing, installation, insulation, protection, transitions, and special fittings of the conduit or piping, as well as access requirements for maintenance, (3) operational and user safety, (4) maintainability, (5) warranties, (6) user acceptance, (7) environmental quality in operation, (8) operational control system, including protective devices in the event of malfunction, etc.

This specification (Appendix F) establishes basic standards and limitations to which the mechanical design engineer and manufacturers must adhere, and provides the necessary guidelines for the comparison and evaluation of the similar systems available. Compliance with certain of these suggested standards must be documented or justified by the manufacturers. The engineers responsible for such review will evaluate the manufacturer's claims.

Concurrently with the development of the basic specifications for the pneumatic solid waste system the Office of Solid Waste Management Program, EPA, developed a Performance Specification for Stationary Solid Waste Compactors (Appendix G). This document provides basic guidelines for evaluation and selection of various types of compaction devices for housing complexes.

Although these specifications may be utilized for any housing project, they were developed principally for application to the Operation Breakthrough projects. Following such application and the selection of specific systems for the demonstration projects, the proposed continuing study (Phase II) will commence. The following section investigates and suggests the scope of work to be undertaken in Phase II as related to the solid waste systems at Memphis and Jersey City.

Research Program Covering the Pneumatic Waste System

Observations and evaluations associated with the demonstration projects may be divided into three major work tasks. These tasks can be identified as the design stage, the construction stage, and operational stage. Each stage of study should be independently reported with the appropriate summations and recommendations. The study should be progressive in nature with qualified review of preceding studies in each subsequent report.

The Design Stage: This initial stage of study will involve working with the individual system designers, manufacturers, site planners, and developers to establish the research protocol to be followed. Concurrently with this activity, instrumentation, monitoring devices, and equipment that will be required should be specified for installation in order to facilitate the following stages of this research.

In addition to the activities associated with the actual system design, all experimental facilities and practices that will be later implemented in the research period should be delineated.

During the design stage it may also be desirable to develop and carry out a test program at the manufacturers' pilot plants on those basic components which have either been modified or specially designed for these projects. With the cooperation of the manufacturer, probable components for testing will include such items as:

1. Chute base valves
2. Tenant operated charging stations
3. Discharge hoppers at central storage location
4. Exhaust air filters and silencers
5. Waste screening devices between receiving hopper and exhaust air discharge line

Such tests would be carried out by independent observers or local testing agencies for the purpose of determining operational capabilities, safety, and maintenance requirements.

Detailed reviews of the total system design should be made at various stages in the design process. Criticism of design details and specifications should be coordinated with the developer and/or designers review of such plans. Final review of the design, prior to approval for construction, should be held jointly by all parties involved. All prior criticisms, not previously resolved, should be redefined and evaluated. Estimated costs of the system should be re-analized with separate identification of accessory devices and equipment required for the research program.

An interim report should be prepared on the design stage for each project. Modification of design evaluation criteria should be made incorporating all changes deemed necessary, identifying those additional parameters which may have materialized during the design process. Such reports should be prepared in collaboration with all parties involved in design.

The Construction Stage: General activities during the construction stage of these systems will include review of contract documents and shop drawings; inspection of special components during fabrication; and site inspections during installation of the piping network, mechanical equipment and control system. Field activity in this stage of work will be concluded with observations during the initial testing period of the system. These activities will be independently carried out, in addition to similar responsibilities of the Site Developer-Planner team. However, findings should be coordinated with their efforts.

Observations and evaluations should be comprehensive in nature with principal goals to include possible improvements and/or economies that could be realized either during the construction stage of these projects, or the design and construction of future projects.

Specific requirements in this stage of work will include the supervision of the installation and testing of all research equipment required for the operational stage of this continuing program.

An interim report will be prepared following the completion of construction and the initial testing of systems at each project. The summation of findings should be concluded with those recommendations in design and construction techniques resulting during this stage of the program.

The Operational Stage: Observations and evaluation of systems operating characteristics will cover such characteristics as the physical and mechanical aspects of the systems operation, systems loadings, environmental quality maintained during operation, and the economic and sociological aspects of systems operation.

The evaluation of the physical and mechanical aspects of the system will require assessment of all components, including chutes, charging units, pipeline, exhausters, filters, discharge hoppers, compactor station, and the control system. Resistance to erosion, corrosion, collapse, and blockage will be among the prime considerations in operation of the storage and transport elements. Adequacy of the automated control system to maintain reliability of operation and prompt identification and location of malfunctions will be of major significance. Facility for prompt maintenance and repair of the total system as well as alternatives during breakdown will also be of prime concern. Such evaluations will consider the design and installation details of this mechanical system, as well as the functional capabilities of all components. Such evaluations may modify design criteria for future project installations.

Observations will be made of the variations of loadings, including types, characteristics, and quantities. Tests will also be conducted to determine maximum loadings and design limitations that may be recommended. Such tests will also include characteristics and limitations of waste materials the system can handle, such as:

1. Maximum density of materials
2. Types of hazardous materials
3. Mixed loose wastes
4. Mixed containerized or bagged wastes
5. Controlled cycling of segregated wastes for recovery
6. Maximum quantities handled by various types of charging stations

Determinations will be made on the advantages and disadvantages of manual activation, time cycle activation, and demand activation of the system for various types of charging stations under differing loading conditions.

The economics of operation will be thoroughly analized considering applicable capital costs, operating costs, and maintenance costs experienced during the program period. The evaluation of direct operating and maintenance costs should consider those modifications of mechanical components and/or the control system where annual economies may be achieved. The economic evaluation should also consider those reduced or increased indirect costs, such as liability and property damage insurance that may be expected. Anticipated future costs will be projected based upon this experience, considered modifications, expected life, and indicated reliability of the total system.

Standards of environmental quality will be evaluated during the operational stage of this program. Such factors as sanitation and safety will be assessed, as well as the esthetic qualities resulting from systems operation. In the latter case, the effectiveness of control over such nuisance characteristics as noise, odors, air pollution, litter, and general appearances normally associated with waste systems, will be fully evaluated. Included in the assessment of safety factors will be the effectiveness of preventive measures against personal injury and property damage resulting from fire, explosions, or general operation of the system. Resident as well as operator safety should be of major significance in this evaluation.

The evaluation of the sociological impact will be based upon on-site observations and investigations of ancillary benefits resulting from the improved methods of transport and minimal storage requirements. Advantages that may be realized by the reduction of service vehicles, and the control of insects and rodents, will be investigated. Periodic interviews with residents, employees, and management will be carried out to determine changing attitudes in the level of acceptance and service of the system, and their assessment of the esthetic quality of its operation. The convenience of the systems, as compared to conventional systems, will be evaluated, as well as their compatibility with the life style of the resident and routines of the employees and management. Such evaluations should indicate those characteristics of systems operation where modifications may be needed to improve user acceptance.

The conclusion of this research program should require a final report which reviews the findings of the design and construction stages of the program, together with comprehensive detail of activities during the operational stage.

The evaluation of these findings should produce adequate specification requirements, design criteria, and operational standards for the application to similar projects in the future.

Research Requirements on Other Recommended Systems

In addition to pneumatic conveyor systems coupled with central compaction stations, as recommended for Memphis and Jersey City, other types of systems to be considered for the research program include various types of compaction devices.

Under-counter compactors were recommended as the preferred system for the King County site. A combination of under-counter compactors (for single family dwelling units) and chute-fed stationary compactors (for multifamily dwelling units) were recommended for the sites at Macon, St. Louis, Indianapolis, Kalamazoo, and Sacramento. Console compactors were recommended to best serve the site at Seattle, but were also considered as an alternative system for the low-rise clustered dwelling units in certain of the other projects.

Various types of collection were considered for these projects, ranging from management operated services to conventional municipal services.

Although it would be desirable for research purposes to implement all systems recommended, it is recognized that funding all projects is unlikely. It is recommended, however, that sites be selected where representative types of these different systems can be installed and included in the research program in Phase II of this study. As in the case of the research program covering the pneumatic conveyor systems, these demonstration projects would be divided into three major work tasks covering the design, construction or installation, and operational phases. Separate and complete reports would be required on each system by phases.

Performance evaluation criteria, comparable in scope and format to Appendices F and G, should be developed initially in the design phase of each of these systems.

The research program would be similar in scope as detailed in the design, construction, and operational phases of the Memphis and Jersey City systems previously discussed.

APPENDIX A
NUMERICAL IDENTIFICATION OF EQUIPMENT MANUFACTURERS

The following list, arranged numerically, identifies the manufacturers shown in tabulations in this report. Elsewhere will be found an alphabetical list of these and other manufacturers, togethe with their addresses. The manufacturers included in the list are for purposes of aiding in the discussions of various types of equipment. The inclusion of any name does not indicate particular approval or recommendation of a particular product nor does any exclusion indicate disapproval.

1000	Hotpoint Dishwasher and Disposal Dept.
1001	National Disposer Co.
1002	Kitchenmaid Dishwasher Div.
1003	Waste King Universal
1004	Whirlpool Corporation
1005	Atomic Disposer Corporation
1006	Kelvinator, Inc.
1007	Bus Boy Disposer, Inc.
1008	In-Sink-Erator
1009	Disposall
2000	Wilkinson Chutes, Inc.

2001	Construction Products, Inc.
3000	International Paper Company
3001	Westvaco
3002	Gilman Paper Company
3003	St. Regis Paper Company
4000	Rubbermaid Commercial Products, Inc.
4001	Mobil Chemical Co.
4002	Phillips Films Co., Inc.
5000	M-B Company
5001	Val-Jac Manufacturing Co., Inc.
6000	Compackager Corporation
6001	Automatic Refuse Systems, Inc.
7000	Auto Pak Company
7001	Mil-Pac Systems, Inc.
7002	Research-Cottrell, Inc.
7003	E-Z Pack Company
7004	Waterbury Hydraulic & Pollution Sciences, Inc.
7005	Compactor Corporation
8000	Loewy Machinery Supplies Co., Inc.
8001	Mil-Pac Systems, Inc.
9000	Auto Pak Company

9001	Dempster Brothers, Inc.
9002	E-Z Pack Company
9003	Anchor Machine Company, Inc.
9004	S. Vincen Bowles, Inc.
9005	Heil Co., (The)
9006	LoDal, Inc.
9007	Industrial Services of America
10000	Chili Plastics, Inc.
10001	County Plastics Corp.
10002	Florsheim Manufacturing Co., Inc.
10003	Refuse Disposal Equipment Co., Inc.
10004	Rubbermaid Commercial Products, Inc.
10005	Grand Aluminum Welding
10006	Metal Edge Industries
11000	Mil-Pac Systems
11001	Eidel International Corporation
11002	Jacksonville Blow Pipe Co.
12000	Cushman Motors
13000	Whirlpool Corporation
14000	Verse Cart Containers
14001	Fusion Rubbermaid Corporation

14002	Moulded Products, Inc.
15000	Compackager Corporation
15001	Logemann Brothers Company

APPENDIX B
PRODUCT LIST
(TYPE, MANUFACTURER, AND TRADE NAME)

Handling Equipment

CART, Collection, Refuse	
Fusion Rubbermaid Corp.	"Mobil Toter"
Moulded Products, Inc.	"Waste Aid"
Versa Cart Containers	
CHUTE, Gravity	
Comstock Engineering Co.	
Construction Products Co., Inc.	"Haslett"
Kirk & Blum Mfg. Co., The	
Lamson Division Diebold, Incorporated	
Matthews Conveyor Co.	
Olson Div. -- American Chain & Cable Co., Inc.	
Standard Conveyor Co.	
Wilkinson Chutes, Inc.	

COLLECTOR, Litter, Vacuum	
Truck Equipment Corporation	"Tecorp"
CONVEYOR, Pneumatic	
Butler Manufacturing Co.	
Eastern Cyclone Industries, Inc.	"Air-Flyte"
Envirogenics Company	"AVAC"
Fisher-Klosterman, Inc.	
Flo-Tronics Air Conveyor Div.	
Fuller Company	"Airveyor"
Lamson Division Diebold, Incorporated	
Montgomery Industries, Inc.	"Trans-Vac"
Quickdraft Corporation	
Salina Manufacturing Co., Inc.	
HOIST, Container, Rear-Loading	
Bremen Equipment Corp.	
Bynal Products, Inc.	"Tripsaver"
Converto Mfg. Co. - Div. of Golay & Co., Inc.	"Convertainer"
Dempster Brothers, Inc.	"Dumpster"

Heil Co., The	"Load Lugger"
Perfection-Cobey Company Div. of Harsco Corp.	"Liftainer"
Western Body & Hoist Co.	
HOIST, Tiltframe, Container, Packer	
Anchor Machine Company, Inc.	"Anchorlift"
S. Vincen Bowles, Inc.	
Converto Mfg. Co. - Div. of Golay & Co., Inc.	"Leav-A-Trainer"
Dempster Brothers, Inc.	"Dinosaur"
E-Z Pack Company	
Gar Wood Industries, Inc.	"Dispos-Haul"
Heil Co., The	"Huge-Haul"
Hobbs Hyd-Pak - Div. of Fruehauf Corp.	"Pack-Saddle"
Industrial Services of America - Tri-Pak Division	"Tri-Pak"
King Container, Inc.	
Perfection-Cobey Company - Div. of Harsco Corp.	"Fleetainer"
Swiftainer Industries Corp.	"Swift-Hoist"
Universal Handling Equipment Co.	

Wayne Engineering Corporation	
Western Body & Hoist Co.	
PACKER, Front-Loader, Mobile	
S. Vincen Bowles, Inc.	
D-V Metal Fab Co. - Div. of Data-Veyor Corp.	
Dempster Brothers, Inc.	"Dumpster"
E-Z Pack Company	
Heil Co., The	
King Container, Inc.	
LoDal, Inc.	"Load-A-Matic"
Pak-Mor Manufacturing Co.	
Perfection-Cobey Company - Div. of Harsco Corp.	"Pak-tainer" & "Fork-tainer"
Sanitary Controls, Inc.	
Toledo Industrial Fabricating Co., Inc.	
Western Body & Hoist Co.	"Full-Pak", "Jet Full-Pak" & "Top-Pak"

PACKER, Rear-Loader, Mobile

Atlas Hoist & Body, Inc.	
City Tank Corp.	"Load-Master" & "Roto-Pac"
Dempster Brothers, Inc.	
Elgin Leach Corp.	"Packmaster"
E-Z Pack Company	
Gar Wood Industries, Inc.	
Heil Co., The	"Colectomatic"
Hobbs Hyd-Pak - Div. of Fruehauf Corp.	"Hyd-Pak"
Jafco Systems	
Pak-Mor Manufacturing Co.	"Load Liner"
Perfection-Cobey Company - Div. of Harsco Corp.	"Cobey"
St. Regis Environmental Systems Div.	
Tampo Mfg. Co., Inc.	"Seal-Press"

PACKER, Side-Loader, Mobile

D-V Metal Fab Co. - Div. of Data-Veyors Corp.	"Fastpack"
E-Z Pack Company	
Hobbs Hyd-Pak - Div. of Fruehauf Corp.	"Com-Pak"

Lodal, Inc.	
Marion Metal Products Co.	
M-B Company	
New Way Manufacture	
Pak-Mor Mfg. Co.	
Perfection-Cobey Company - Div. of Harsco Corp.	"Swift-Pak"
H.E. Smith, Inc.	"Smithpac"
Sterling Mfg. Co.	"Hippo"
Tampo Mfg. Co., Inc.	"Seal-Press"
Truck Equipment Corp.	"Truxmore Pakker"
Val-Jac Mfg. Co., Inc.	"Pak-Rat"
Wayne Engineering Corp.	"Mighty-Pack"
Western Body & Hoist Co.	"Shu-Pak"
PACKER, Trailer	
Dempster Brothers, Inc.	
Elgin Leach Corp.	
Gar Wood Industries, Inc.	
King Container, Inc.	

M-B Company	"Moto-Pack"
H.E. Smith, Inc.	"Portapac"
Val-Jac Mfg. Co., Inc.	"Pak-Rat-Pup"
Wayne Engineering Corp.	"Mighty-Pack"
TRAIN, Container	
Dempster Brothers, Inc.	
Elgin Leach Corporation	
E-Z Pack Co.	
LoDal, Inc.	
Perfection-Cobey Co. - Div. of Harsco Corp.	
Sanitary Controls, Inc.	
Truck Equipment Corporation	"Trux-Train"
VEHICLE, Collection, Satellite	
A-Manufacturing Co., Inc.	
Cushman Motors - Division of Outboard Marine Corp.	
Portec Inc., Butler Division	
Systems Manufacturing Corp.	
Trash Mobile - Division of Hanna	
West Coast Machining	

Storage Equipment

BAG, Paper, Disposable

Bancroft Bag, Inc.	
Bemis Co., Inc.	
Crown-Zellerback Corp.	
Gilman Paper Co.	"DisPOzit!"
Hudson Pulp and Paper Co.	
International Paper Co.	"Garbax"
St. Regis Environmental Systems Division	
Southern Bag Corp.	
Union Camp Corp.	
U.S. Gypsum Co.	
West Virginia Pulp and Paper Corp.	"Westvaco"

BAG, Plastic, Disposable

- American Can Co.
- Bemis Co., Inc.
- Broyhill Industries
- Cherrin Products Co.
- Ethyl Corporation
- Extrudo Film Corp.
- Gulf Plastic Products Co.

Handi-Bag Corp.	
Mobil Chemical Co. - Plastics Division	
Monsanto Co. - Plastic Products and Resins Division	
Phillips Films Co., Inc. - Subsidiary of Phillips Petroleum Co.	"Piggie Pokes"
W. Ralston & Co., Ltd.	
Rapco Plastics, Inc.	
Republic Molding Corp.	
Rexall Chemical Co.	
Rubbermaid Commercial Products, Inc.	
St. Regis Environmental Systems Division	
Sinclair-Koppers Co.	
Surrey Steel Components Ltd.	
Union Carbide Corp.	
USI Film Products - Div. of U.S. Industrial Chemical Co.	
Walton-March	

Webster Industries, Inc. - Environmental Controls Products Division - Subsidiary of Chelsea Industries, Inc.

The Witt Co.

BARREL, Aluminum

- Grand Aluminum Welding

BARREL, Plastic

Chili Plastics, Inc.	"Chilite Toter"
County Plastics Corp.	
Florsheim Mfg. Co., Inc.	
Refuse Disposal Equipment Co., Inc.	"Aerospace"
Rubbermaid Commercial Products, Inc.	"Brute Group"

CART, Aluminum, Hand-pushed

- McClintock Division - Unarco Industries, Inc.
- Rol-Away Truck Mfg. Co., Inc.

CART, Fiberglas, Hand-pushed

- Container Development Corp.

CART, Steel, Hand-pushed	
Bloomfield/Silex Industries, Inc.	
Fort Steuben Metal Products Co.	
McClintock Division - Unarco Industries, Inc.	
Metropolitan Wire Goods Corp.	
Republic Steel Corp.	
Tradewind Industries, Inc.	
CART, Packer, Stationary	
E-Z Pack Company	"E-Z Pack Trash Cart"
Swiftainer Industries Corp.	
CONTAINER, Front-Loader, Packer, Mobile	
Burtman Iron Works	"Dyna-Bilt"
Bynal Products, Inc.	"Hand-E-Can"
Dempster Brother, Inc.	
E-Z Pack Company	
Gen Sani-Can Corporation	
King Container, Inc.	
LoDal, Inc.	"Load-A-Matic"
National Compactor & Technology Systems, Inc.	

New York Sani-Can, Inc.	
Pak-Mor Manufacturing Co.	
Universal Handling Equipment Co.	
CONTAINER, Rear-Loader, Packer, Mobile	
Apex Metal Products	
Burtman Iron Works	"Dyna-Bilt"
Bynal Products, Inc.	"Hand-E-Can"
Elgin Leach Corporation	
E-Z Pack Company	
Gen Sani-Can Corp.	
King Container, Inc.	
National Compactor & Technology Systems, Inc.	
New York Sani-Can, Inc.	
Pak-Mor Manufacturing Co.	
Universal Handling Equipment Co.	
CONTAINER, Side-Loader, Packer, Mobile	
Burtman Iron Works	"Dyna-Bilt"
Bynal Products, Inc.	"Hand-E-Can"
Gen Sani-Can Corp.	

Hobbs Hyd-Pak	
King Container, Inc.	
National Compactor & Technology Systems, Inc.	
Pak-Mor Manufacturing Co.	"Handi-Lift"
Tampo Manufacturing Co., Inc.	"Seal-Press"
Truck Equipment Corp.	"Truxmore Container"
Universal Handling Equipment Co.	
Val-Jac Manufacturing Co., Inc.	
CONTAINER, Open-top, Roll-off	
Bremen Equipment Corp.	
Gar Wood Industries, Inc.	"Dispos-Haul"
Heil Co., The	"Huge-Haul"
CONTAINER, Rear-Loading	
Apex Metal Products	"Spill-Tainer"
Bynal Products, Inc.	
Converto Mfg. Co.	
Dempster Brothers, Inc.	
Heil Co., The	"Load-Lugger"
Perfection-Cobey Company	

CONTAINER, Receiving, Packer, Stationary

Anchor Machine Co., Inc.	"Anchortainer"
Auto Pak Co.	"Dual-Pak"
S. Vincen Bowles, Inc.	
Dempster Brothers, Inc.	
E-Z Pack Company	
Heil Co., The	"Huge-Pac"
Hobbs Hyd-Pak	
Industrial Services of America	"Tri-Pak"
King Container, Inc.	
Marathon Equipment Co., Inc.	"Ram-Jet"
National Compactor & Technology Systems, Inc.	
New York Sani-Can, Inc.	
Swiftainer Industries Corp.	"Swiftainer"
Tubar Waste Systems	"Tubartainer"

Processing Equipment

BALER, Bag-Type

(Compactor Bag)

Automatic Refuse Systems, Inc.	"ARS"
Auto Pak Co.	"Gobbler"
Compaction Equipment Co., Inc.	"Gator"
Compactor Corp.	"Wastepactor"
E-Z Pack Company	
Mil-Pac Systems, Inc.	
Piezo Manufacturing Corp.	"Piezo-Pak"
Research-Cottrell, Inc.	
Waterbury Hydraulics & Pollution Sciences, Inc.	

BALER, Carrousel-type

(Compactor, Rotary)

Loewy Machinery Supplies Co., Inc.	"Kompex"
Mil-Pac Systems, Inc.	

BALER, Portable

- Maren Engineering Corp.
- Tamaker Corp.

BALER, Stationary

- American Baler Machine Co. - Div.
  Nat'l. Compactor & Technology Systems, Inc.
- Compackager Corporation
- Consolidated Baling Machine Co.
- Logemann Bros. Co.
- Tamaker Corp.

CHIPPER, Brush

- Wayne Manufacturing Co.

COLLECTOR, Dust, Bag-type

- John Zink Co.

COLLECTOR, Dust, Centrifugal

- Fisher-Klosterman, Inc. — "Balanced Air" & "Cluster-Clone"

COLLECTOR, Dust, Cyclone

- Balemaster Div - East Chicago
  Machine Tool Corp.
- Bartlett-Snow
- Eastern Cyclone Industries, Inc. — "ECI" & "Air-Flyte"

Fisher-Klosterman, Inc.	"Balanced Air" & "Cluster-Clone"
Gruendler Crusher & Pulverizer Co.	
Quickdraft Corporation	
Salina Manufacturing Co., Inc.	
Williams Patent Crusher & Pulverizer Co., Inc.	
John Zink Company	
COMPACTOR, Bag	
Auto Pak Co.	
Compactor Corp.	"Wastepactor"
E-Z Pack Company	
Mil-Pac Systems, Inc.	
Research-Cottrell, Inc.	
Waterbury Hydraulic & Pollution Sciences, Inc.	
COMPACTOR, Console	
Compackager Corporation	"Trash Masters"
Automatic Refuse Systems, Inc.	"ARS"
COMPACTOR, Rotary	
Loewy Machinery Supplies Co.	"Kompex"
Mil-Pac Systems, Inc.	

COMPACTOR, Stationary

American Johnson Compactor Co., Inc.	
Anchor Machine Company, Inc.	"Anchorpac"
Apex Metal Products - Div. of Hydraulic Refuse Systems Corp.	"Concentrator"
Automatic Refuse Systems, Inc.	
Auto Pak Company	"Dual-Pak" & "Pitch 'N Pak"
S. Vincen Bowles, Inc.	
Compaction Equipment Co., Inc.	"Pac-King"
Compactor Corp.	"Wastepactor"
Data-Veyors Corp.	
Dempster Brothers, Inc.	"Dinopacker II"
Ecological Assistance Corp.	
E-Z Pack Company - Div. of Hercules Galion Products, Inc.	
Gladco Compactors, Inc.	
Gull Products Co.	
Heil Co., The	"Huge-Pac"
Hobbs Hyd-Pak - Div. of Fruehauf Corp.	"Hyd-Pak"

Industrial Services of America, Inc.	"Tri-Pak"
King Container, Inc.	
Lodal Inc.	
Machine Products Corp.	
Marathon Equipment Co., Inc.	"Ram-Jet"
McDowell-Wellman Co.	
McMearty Equipment Co., Inc.	"Pak-King"
Mid Equip. Corp.	
Mil-Pac Systems - Unit of SFM Corp.	
Moto-Pack M-B Co.	
National Compactor & Technology Systems, Inc.	
New York Sani-Can, Sanitary Controls, Inc.	
Pak-Mor Manufacturing Co.	
Perfection-Covey Company - Div. of Harsco Corp.	"Station-pak"
Piezo Manufacturing Corp.	
Seco Electronics Corp.	
Swiftainer Industries Corp.	"Swift-Pac"
Toledo Industrial Fabricating Co., Inc.	

Tri-Pak Division - Tri-City Industrial Services, Inc.	
Tubar Waste Systems	"Tubartainer"
Universal Handling Equip. Co.	
Western Body & Hoist Co.	
COMPACTOR, Undercounter	
Whirlpool Corporation	"Trash Masher"
CRUSHER, Bottle	
Qualheim, Inc.	
CRUSHER, Can	
Qualheim, Inc.	
GRINDER, Dry	
Buffalo Hammer Mill Corp.	
Eidal International Corp.	"Mini-Mill"
Ecological Assistance Corp.	"EAC/Refuse Compactor"
Gruendler Crusher and Pulverizer Co.	
Jacksonville Blow Pipe Co.	
Mil-Pac Systems, Inc. - Unit of SMF Corporation	
Williams Patent Crusher and Pulverizer Co., Inc.	

GRINDER, In-sink

(Grinder, Wet)

Atomic Disposer Corp.	"Atomic"
Bus Boy Disposer, Inc.	"Bus Boy"
Disposall - General Electric Company	"Disposall"
FMC Corporation	
In-Sink-Erator Mfg. Co.	"In-Sink-Erator"
Kelvinator, Inc.	"Kelvinator"
Kitchen Aid	"Hobart"
National Disposer Co.	"Hobart"
Salvajor Company	
Swimquip Inc.	
Waste King Universal	"Waste King Universal"
Whirlpool	"Whirlpool"

HOGGER

Balemaster Div. - East Chicago Machine Tool Corp.	"Cyclomatic"
Gruendler Crusher & Pulverizer Co.	
Jacksonville Blow Pipe Co.	"Montgomery Blo-Hog"

Logemann Bros. Co.	
Stedman Foundry & Machine Co., Inc.	"Nife-Less"
The Engineer Company	"TEC Convept"
Williams Patent Crusher & Pulverizer Co., Inc.	"No-Nife"
INCINERATOR	
Air Preheater Company, Inc.	"Combustall"
American Incinerator Corp.	
Automated Disposal Systems, Inc.	"Disposacon"
Brule Incinerators	
Calcinator Corporation	"Calcinators"
Combustion Engineering, Inc.	"Combustopak"
Comtro, Inc.	"Comtro"
Despatch Oven Company	"Des-Inerator"
Federal Enterprises	"Federal Enterprises
Garver-Davis, Inc.	"Destructur"
Joseph Goder Incinerators	
I.P.C. Industries	
Midland-Ross Corporation	"Radicator"
Morse Bougler - Div. of Hagan Industries, Inc.	

Nash, Cadmus & Voelker, Inc.	
Nichols Engineering & Research Corp.	
Plibrico Company	
Sargent NCV Division of Zurn Industries, Inc.	
Silent Glow Corp.	"Hydrox-O-Lator"
Smokatrol, Inc.	"Smokatrol"
Thermal Research & Engineering Corp.	
Vulcan Iron Works, Inc.	
Waste Combustion Corporation	"Consumat"
Wasteco, Inc.	"Wasteco"
PULPER	
Black Clawson Company, The	"Chemi-Pulper"
Somat Corp.	
Wascon Systems, Inc.	
PULVERIZER, Paper	
Pacific Cutter Co., Inc.	
W-W Grinder Corp., The	
SHREDDER	
American Baler Co., The	
American Pulverizer Co.	
Gruendler Crusher & Pulverizer Co.	

Hammermills, Inc.	"Bull Dog"
Pennsylvania Crusher Corp.	
Stedman Foundry and Machine Co., Inc.	
Williams Patent Crusher and Pulverizer Co., Inc.	"Fragmenitzer"

APPENDIX C
ALPHABETICAL LISTING OF EQUIPMENT MANUFACTURERS

A-Manufacturing Co., Inc.
P. O. Box 6
Bedford, Texas 76021

Aerojet-General Corporation
(see Envirogenics Co.)
Environmental Systems Division
9200 East Flair Drive
El Monte, California 91734

Air Preheater Company
Wellsville, New York 14895

Al-Jon, Inc.
P. O. Box 592
Ottumwa, Iowa 52505

Alvey Conveyor Manufacturing Co.
9301 Olive Boulevard
St. Louis, Missouri 63132

American Baler Company, (The)
1000 Hickory Street
Bellevue, Ohio 44811

American Baler Machine Company
Div. National Compactor & Technology
Systems, Inc.
839 - 39th Street
Brooklyn, New York 11232

American Can Co.
Plastics Division
100 Park Avenue
New York, New York 10017

American Incinerator Corp.
5710 East Nevada
Detroit, Michigan 48234

American Johnson Compactor Co., Inc.
839 - 39th Street
Brooklyn, New York 11232

American Pulverizer Company
1249 Macklind Avenue
St. Louis, Missouri 63110

Anchor Machine Company, Inc.
P. O. Box 260
Jackson, Michigan 49204

Apex Metal Products
Div. of Hydraulic Refuse Systems Corp.
101 Louise Street
Rochester, New York 14606

Atlas Hoist & Body, Inc.
7600 Cote de Liesse Road
Montreal 376
Quebec, Canada

Atomic Disposer Corp.
7110 Fenwick Lane
Westminster, California 92683

Auto Pak Company
4908 Lawrence Street
Bladensburg, Maryland 20710

Automated Disposal Systems, Inc.
1401 Ellsworth Industrial Blvd.
P. O. Box 19858
Atlanta, Georgia 30325

Automatic Refuse Systems, Inc.
33201 Harper Avenue
St. Clair Shores, Michigan 48083

Balemaster Div.
East Chicago Machine Tool Corp.
4801 Railroad Avenue
East Chicago, Indiana

Bancroft Bag, Inc.
P. O. Box 307
West Monroe, Louisiana 71291

Barlett-Snow
6200 Harvard Avenue
Cleveland, Ohio 44105

Bauer Bros. Co., (The)
P. O. Box 968
Springfield, Ohio 45501

Bemis Co., Inc.
800-T Northstar Center
Minneapolis, Minnesota

Black Clawson Company, (The)
Shartle Division
Pandia Division
Middletown, Ohio 45042

Bloomfield/Silex Industries, Inc.
4546 W. 47th Street
Chicago, Illinois 60632

S. Vincen Bowles, Inc.
12039 Branford Street
Sun Valley, California

Bremen Equipment Corp.
3113 So. Gertrude Street
P. O. Box 2656
South Bend, Indiana 46613

Broyhill Industries
Polymer Processing Division
Lenore, North Carolina 28645

Brule ("Bru-lay") Incinerators
13920 South Western Avenue
Blue Island, Illinois 60406

Buffalo Hammer Mill Corp.
1245 McKinley Parkway
Buffalo, New York 14218

Burtman Iron Works
Readville, Massachusetts 02137

Bus Boy Disposer, Inc.
Amsco Div., Champion Industries, Inc.
13150 Saticoy Street
North Hollywood, California 91605

Butler Manufacturing Co.
7400 East 13th Street
Kansas City, Missouri 64126

Bynal Products, Inc.
11990 Franklin Avenue
Franklin Park, Illinois 60131

Calcinator Corporation
P. O. Box 400
Bay City, Michigan 48706

Central Vac International
3008 E. Olympic Boulevard
Los Angeles, California 90023

Cherrin Products Co.
6340 Miller Road
Dearborn, Michigan 48126

Chili Plastics, Inc.
2278 Westside Drive
Rochester, New York 14624

City Tank Corporation
Box 711
Culpeper, Virginia 22701

Combustion Engineering, Inc.
Windsor, Connecticut 06095

Compackager Corporation
2135 Wisconsin Avenue, N.E.
Washington, D.C. 20007

Compaction Equipment Company, Inc.
P. O. Box 2206
Silver Spring, Maryland 20902

Compactor Corp.
Subsidiary of Carrier Corp.
25-33 Edward J Hart Road
Jersey City, New Jersey 07305

Compactor Refuse Handling Systems
900 North 137th Avenue
Seattle, Washington 98133

Comstock Engineering Co.
2311 East Eighth Street
Los Angeles, California

Comtro, Inc.
North Wales, Pennsylvania 19454

Consolidated Baling Machine Company
Division, N.J. Cavagnaro & Sons
Machine Corp.
400 Third Avenue
Brooklyn, New York 11215

Construction Products, Inc.
Route #7
Brookfield, Connecticut 06804

Container Development Corp.
Watertown, Wisconsin 53094

Converto Mfg. Co.
Div. of Golay & Co., Inc.
Cambridge City, Indiana 47327

County Plastics Corp.
100 Verdi Street
Farmingdale, New York 11735

Crown-Zellerback Corp.
One Bush Street
San Francisco, California 94119

Cushman Motors
Division of Outboard Marine Corp.
10004 N. 21st Street
Lincoln, Nebraska 68501

D-V Metal Fab Co.
(Div. of Data-Veyors Corp.)
3246 Ettie Street
Oakland, California 94608

Data-Veyors Corp.
3250 Ettie Street
Oakland, California 94608

Dempster Brothers, Inc.
P. O. Box 3127
Knoxville, Tennessee 37917

Despatch Oven Company
P. O. Box #1320
Minneapolis, Minnesota 55414

Disposall
Dishwasher and Disposall Dept.
General Electric Company
Appliance Park, Louisville, Kentucky 40225

E-Z Pack Company
(Div. of Hercules Galion Products, Inc.)
P. O. Box 607
Galion, Ohio 44833

Eastern Cyclone Industries, Inc.
15 Daniel Road
Fairfield, New Jersey 07006

Ecological Assistance Corp.
18-01 Pollitt Drive
Fair Lawn, New Jersey 07401

Eidal International Corporation
245 Woodward Road, S.W.
Alburquerque, New Mexico 87103

Elgin Leach Corporation
222 West Adams Street
Chicago, Illinois 60606

Envirogenics Company
Div. of Aerojet-General Corp.
9200 East Flair Drive
El Monte, California 91734

Ethyl Corporation
330 South Fourth Street
Richmond, Virginia 23217

Extrudo Film Corp.
111 West 50th St.
New York, New York 10019

Federal Enterprises, Inc.
2800 W. Battlefield Road
Springfield, Missouri 65804

Fisher-Klosterman, Inc.
2901 Magazine Street
Louisville, Kentucky 40211

Florsheim Manufacturing Company, Inc.
825 No. Lessing Street
Chicago, Illinois 60622

Flo-Tronics
Air Conveyor Div.
1820 Xenium Lane
Minneapolis, Minnesota 55427

FMC Corporation
Hoopeston, Illinois 60942

Fort Steuben Metal Products Co.
Fort Steuben Road
Weirton, West Virginia

Fuller Company
123 Bridge Street
Catasauqua, Pennsylvania 18032

Fusion Rubbermaid Corporation
Box 5338
Statesville, North Carolina 28677

Gar Wood industries, Inc.
Wayne, Michigan 48184

General Hydraulics of California, Inc.
411 South Flower Street
Burbank, California 91502

Gen Sani-Can Corp.
21 Gear Avenue
Lindenhurst, New York 11757

Gilman Paper Company
Kraft Bag Division (DisPOzit Div.)
Time & Life Building, Rockefeller Center
111 West 50th Street
New York, New York 10020

Gladco Compactors, Inc.
14500 Eureka Road
Southgate, Michigan 48195

Goder Incinerators, Joseph
2483 Greenleaf Avenue
Elk Grove Village, Illinois 60007

Grand Aluminum Welding
1232 Commercial Street, N.E.
Salem, Oregon 97301

Gruendler Crusher and Pulverizer Co.
2915 No. Market Street
St. Louis, Missouri 63106

Gulf Plastic Products Co.
Gulf Oil Corp.
200 Maltese Drive
Totowa, New Jersey 07512

Gull Products Co.
1523 N. Burdick Street
Kalamazoo, Michigan 49007

Hammermills, Inc.
(Subsidiary-Pettibone Mulliken Corp.)
625 "C" Avenue, N.W.
Cedar Rapids, Iowa 52405

Handi-Bag Corp.
181 Spencer Avenue
Chelsea, Massachusetts 02150

Heil Co., (The)
3000 W. Montana Street
Milwaukee, Wisconsin 53201

Hobbs Trailers
Division of Fruehauf Corp.
609 North Main
Fort Worth, Texas 76106

Hotpoint Dishwasher & Disposall Dept.
General Electric Company
Appliance Park, Louisville, Kentucky 40225

Hudson Pulp and Paper Co.
477 Madison Avenue
New York, New York 10017

I.P.C. Industries
687 So. Post Avenue
Detroit, Michigan 48217

Indiana General
Magnetic Equipment Div.
6001 South General Avenue
Dudahy, Wisconsin 53110

Industrial Services of America
Tri-Pak Division
P. O. Box 21-070
Louisville, Kentucky 40221

In-Sink-Erator
Div. of Emerson Electric Co.
4700 21st Street
Racine, Wisconsin 53406

International Paper Company
Garbax Disposal System
220 East 42nd Street
New York, New York 10017

Jacksonville Blow Pipe Co.
P. O. Box 3687
Jacksonville, Florida 32206

Jafco Systems
5 W. Street
Hyde Park, Massachusetts 02136

Kelvinator, Inc.
1545 Clyde Park Avenue, S.W.
Grand Rapids, Michigan 49509

King Container, Inc.
1111 South 12th Street
Kansas City, Kansas 66105

Kirk & Blum Manufacturing Co., (The)
3120 Forrer Street
Cincinnati, Ohio

Kitchen Aid Dishwasher Division
The Hobart Manufacturing Co.
Troy, Ohio 45373

Lamson Division
Diebold, Incorporated
Lamson Street
Syracuse, New York 13201

LoDal, Inc.
Kingsford, Michigan 49802

Loewy Machinery Supplies Co., Inc.
305 East 47th Street
New York, New York 10017

Logemann Brothers Company
3150 West Burleigh Street
Milwaukee, Wisconsin 53245

McClintock Division
Unarco Industries, Inc.
15005 So. Marquardt Avenue
Santa Fe Springs, California 90670

McDowell-Wellman Co.
113 St. Clair Avenue, N.E.
Cleveland, Ohio 44114

McMearty Equipment Co., Inc.
8830 Piney Branch Road
P. O. Box 1988
Silver Springs, Maryland 20902

M-B Company
1635 Wisconsin Avenue
New Holstein, Wisconsin 53061

Machine Products Corp.
1111 South 12th Street
Kansas City, Kansas 66105

Marathon Equipment Co., Inc.
1300 Borden Avenue
P. O. Box 160
Leeds, Alabama 35094

Maren Engineering Corporation
16246 School Street
P. O. Box 143
South Holland, Illinois 60473

Marion Metal Products Co.
Marion, Ohio

Matthews Conveyor Company
190 Tenth Street
Ellwood City, Pennsylvania

Metal Edge Industries
Barrington, New Jersey 08007

Metropolitan Wire Goods Corp.
N. Washington St. & George Ave.
Wilkes-Barre, Pennsylvania 18705

Mid Equip. Corp.
Highway 175 West
Grundy Center, Iowa 50638

Midland-Ross Corporation
P. O. Box 751
New Brunswick, New Jersey 08903

Mil-Pac Systems, Inc.
1110 Globe Avenue
Mountainside, New Jersey 07092

Mobil Chemical Co.
Plastics Division
3848 Richard Street
Macedon, New York 14502

Monsanto Co.
Plastic Products and Resins
Division
200 North Seventh St.
Kenilworth, New Jersey 07033

Monsanto Enviro-Chem Systems, Inc.
800 North Lindbergh Boulevard
St. Louis, Missouri 63166

Montgomery Industries, Inc.
2017 Thelma Street
Jacksonville, Florida 32206

Morse Boulger
Div. of Hagan Industries, Inc.
53-09 - 97th Place
Corona, New York 11368

Moulded Products, Inc.
Maple Plain, Minnesota 55359

Nash, Cadmus & Voelker, Inc.
70 West Sunrise Highway
Freeport, New York 11520

National Compactor & Technology
Systems, Inc.
839 - 39th Street
Brooklyn, New York 11232

National Disposer Co.
Div. of the Hobart Manufacturing Co.
Troy, Ohio 45373

New Way Manufacture
600 N.E. 48th Place
Des Moines, Iowa 50313

New York Sani-Can, Inc.
225 Marcus Boulevard
Deer Park, New York 11729

Nichols Engineering & Research Corp.
150 William Street
New York, New York 10038

Olson Division
American Chain & Cable Co., Inc.
10601 W. Belmont Avenue
Franklin Park, Illinois 60131

Pacific Cutter Co., Inc.
3690 Santa Fe Avenue
Los Angeles, California 90058

Pak-Mor Manufacturing Company
1123 S.E. Military Drive
P. O. Box 14147
San Antonio, Texas 78214

Pennsylvania Crusher Corporation
Subsidiary of Bath Industries, Inc.
Box 100
Broomal, Pennsylvania 19008

Perfection-Cobey Company
Div. of Harsco Corp.
Galion, Ohio 44833

Phillips Films Co., Inc.
Polyolefin Division
(Subsidiary--Phillips Petroleum Co.)
5570 Creek Road
Cincinnati, Ohio 45242

Piezo Manufacturing Corporation
193 Main Street
Madison, New Jersey 07940

Plibrico Company
1800 N. Kingsbury Street
Chicago, Illinois 60614

Portec Inc.
Butler Division
P. O. Box 678
Waukesha, Wisconsin 53186

Qualheim, Inc.
1225 - 14th Street
P. O. Box 368
Racine, Wisconsin 53403

Quickdraft Corporation
1525 Perry Drive, S.W.
Canton, Ohio 44708

W. Ralston & Co., Ltd.
Rexdale, Canada

Rapco Plastics, Inc.
P. O. Box 659
612 E. McKinney
Denton, Texas 76201

Refuse Disposal Equipment Co., Inc.
P. O. Box 421
Highland Park, Illinois 60035

Republic Molding Corp.
6330 W. Touhy Avenue
Chicago, Illinois 60648

Republic Steel Corporation
1315 Albert Street
Youngstown, Ohio 44505

Research-Cottrell, Inc.
Box 750
Bound Brook, New Jersey 08805

Rexall Chemical Co.
P. O. Box 37
Wills Century Road
Paramus, New Jersey 07652

Rogers Manufacturing Co., Inc.
220 No. Mahaffie
Olathe, Kansas 66061

Rol-Away Truck Manufacturing Co., Inc.
6143 S.E. Foster Road
Portland, Oregon 97206

Rubbermaid Commercial Products, Inc.
Winchester, Virginia 22601

Rudolph Poultry Equipment Co.
Vineland, New Jersey 08360

St. Regis Environmental Systems
Division
633 Third Avenue
New York, New York 10017

Salina Manufacturing Co., Inc.
606 N. Front Street
P. O. Box 26
Salina, Kansas 67401

Salvajor Company
4530 East 75th Terrace
Kansas City, Missouri 64132

Sanitary Controls, Inc.
(N.Y. Sani-Can)
225 Marcus Blvd.
Deer Park, New York 11729

Sargent NCV Division
of Zum Industries, Inc.
610 Devon Street
Kearny, New Jersey 07032

Seco Electronics Corp.
1001 Second Street, South
Hopkins, Minnesota 55343

Shredmaster Corporation, (The)
891 South Ocean Avenue
Freeport, L.I., New York 11520

Silent Glow Corporation
850 Windsor Street
Hartford, Connecticut 06101

Sinclair-Koppers Co.
Dept. TR69
Koppers Bldg.
Pittsburgh, Pennsylvania 15219

H.E. Smith Inc.
2300 Cole Street
Birmingham, Michigan 48008
or
1069 S. Jackson Street
Defiance, Ohio

Smokatrol, Inc.
66th Pulaski Highway
Baltimore, Maryland 20237

Somat Corporation
Box 831
Coatesville, Pennsylvania 19320

Southern Bag Corp.
P. O. Box 389
Yazoo City, Mississippi

Standard Conveyor Company
940 Indiana Avenue
North St. Paul, Minnesota 55109

Stedman Foundry and Machine Company, Inc.
Subsidiary-United Engrg. & Foundry Co.
Aurora, Indiana 47001

Sterling Manufacturing Company
241 North Third Street
Laurens, Iowa 50554

Sturtevant Mill Company
Park and Clayton Street
Boston, Massachusetts 02122

Surrey Steel Components Ltd.
Surrey Sac
High Street
Barnes, London S.W.B.

Swiftainer Industries Corp.
2345 Hollers Avenue
Bronx, New York 10469

Swimquip, Inc.
3301 Gilman Road
El Monte, California 91732

Systems Manufacturing Corp.
Box 610
Corvallis, Oregon 97330

T & S Equipment Company
Albion, Michigan 49224

Tamaker Corp.
P. O. Box 204
Ventura, California 93002

Tampo Manufacturing Company, Inc.
Seal Press Refuse Collection Body Div.
1146 West Laurel Street
P. O. Box 7248
San Antonio, Texas 78207

Toledo Industrial Fabricating Co., Inc.
1100 Bush Street
Box 3556 Station D
Toledo, Ohio 43608

Tradewind Industries, Inc.
P. O. Box 96
Liberal, Kansas 67901

Trash Mobile
Division of Hanna Enterprises
1122 Williams Avenue
P. O. Box 3736
Portland, Oregon 97208

Tri-Pak Division
Tri-Pak Industrial Services, Inc.
7100 Grade Lane
P. O. Box 21070
Louisville, Kentucky 40221

Truck Equipment Corporation
9400 Midlothean Turnpike
Richmond, Virginia 23235

Tubar Waste Systems
Div. of Uhrden, Inc.
Sugarcreek, Ohio 44681

USI Film Products
Division of U.S. Industrial
Chemical Co.
41 Brooklyn Avenue
Brooklyn, New York 11216

Union Camp Corp.
1600 Valley Road
Wayne, New Jersey 07470

Union Carbide Corp.
Chemicals and Plastics
270 Park Avenue
New York, New York 10017

U.S. Gypsum Co.
Oakmont Packaging Division
1155 Allegheny Avenue
Oakmont, Pennsylvania 15139

Universal Handling Equip. Co.
100 Burland Crescent
Hamilton, Ontario

Vacuum Can Company
19 South Hoyne Avenue
Chicago, Illinois 60612

Val-Jac Manufacturing Co., Inc.
5650 N. Broadway
Wichita, Kansas 67219
or
110 N. Park
Maize, Kansas 67101

Versa Cart Containers
P. O. Box 142
Northbrook, Illinois 60062

Vulcan Iron Works, Inc.
Wilkes-Barre, Pennsylvania

W-W Grinder Corporation (The)
2957 North Market
Wichita, Kansas 67219

Walton-March
1620 Old Deerfield Rd.
P. O. Box 340
Highland Park, Illinois 60035

Wascon Systems, Inc.
Subsidiary -- Robins & Myers
210 Bonair Avenue
Harboro, Pennsylvania 19040

Waste Combustion Corporation
P. O. Box 6295
Richmond, Virginia 23230

Waste King Universal
3300 East 50th Street
Los Angeles, California 90058

Wasteco, Inc.
17825 S.W. Pacific Highway
Sherwood, Oregon 97140

Waterbury Hydraulic & Pollution Sciences, Inc.
58 Lafayette Street
Waterbury, Connecticut 06798

Wayne Engineering Corp.
1st and Iowa Streets
Cedar Falls, Iowa 50613

Wayne Manufacturing Co.
1201 East Lexington Street
Pomona, California 91766

Webster Industries Inc.
Environmental Control Products
Division
A Subsidiary of Chelsea Industries, Inc.
58 Pulaski St.
Peabody, Massachusetts 01960

West Coast Machining
P. O. Box 8600
Stockton, California 95204

West Virginia Pulp and Paper Corp.
Bag Division, Papercan System
P. O. Box 5207
North Charleston, South Carolina 29406

Western Body & Hoist Co.
8901 Juniper Street
Los Angeles, California 90002

Westvaco
Bag Division
Box 5207
North Charleston, Charleston County
South Carolina 29406

Whirlpool Corporation
Benton Harbor, Michigan 49022

Wilkinson Chutes, Inc.
619 East Tallmadge Avenue
Akron, Ohio 44310

Williams Patent Crusher and Pulverizer
Co., Inc.
2701 North Broadway
St. Louis, Missouri 63102

The Witt Co.
4454 Steel Place
Cincinnati, Ohio 45209

Zink Company, John
4401 South Peoria
Tulsa, Oklahoma 74105

APPENDIX D

CLASSIFICATION OF WASTES AND INCINERATORS

The basis for satisfactory incinerator operation is the proper analysis of the waste to be destroyed, and the selection of proper equipment to best destroy that particular waste.

As a guide, mixtures of waste most commonly encountered have been classified into types of waste, together with the B.T.U. values and moisture contents of the mixtures. A concentration of one specific waste in the mixture may change the B.T.U. value and/or the moisture content of the mixture. A concentration of more than 10% by weight of catalogues, magazines, or packaged paper will change the density of the mixture and affect burning rates.

Similarly, incinerators have been classified, by their capacities and by the type of wastes they are capable of incinerating.

CLASSIFICATION OF WASTES

Type 0 — Trash, a mixture of highly combustible waste such as paper, cardboard, cartons, wood boxes, and combustible floor sweepings, from commercial and industrial activities. The mixtures contain up to 10% by weight of plastic bags, coated paper, laminated paper, treated corrugated cardboard, oily rags and plastic or rubber scraps.

This type of waste contains 10% moisture, 5% incombustible solids and has a heating value of 8500 B.T.U. per pound as fired.

Type 1 — Rubbish, a mixture of combustible waste such as paper, cardboard cartons, wood scrap, foliage and combustible floor sweepings, from domestic, commercial and industrial activities. The mixture contains up to 20% by weight of restaurant or cafeteria waste, but contains little or no treated papers, plastic or rubber wastes.

This type of waste contains 25% moisture, 10% incombustible solids and has a heating value of 6500 B.T.U. per pound as fired.

Type 2 — Refuse, consisting of an approximately even mixture of rubbish and garbage by weight.

This type of waste is common to apartment and residential occupancy, consisting of up to 50% moisture, 7% incombustible solids, and has a heating value of 4300 B.T.U. per pound as fired.

Type 3 — Garbage, consisting of animal and vegetable wastes from restaurants, cafeterias, hotels, hospitals, markets, and like installations.

This type of waste contains up to 70% moisture, up to 5% incombustible solids, and has a heating value of 2500 B.T.U. per pound as fired.

Type 4 — Human and animal remains, consisting of carcasses, organs and solid organic wastes from hospitals, laboratories, abattoirs, animal pounds, and similar sources, consisting of up to 85% moisture, 5% incombustible solids, and having a heating value of 1000 B.T.U. per pound as fired.

Type 5 — By-product waste, gaseous, liquid or semi-liquid, such as tar, paints, solvents, sludge, fumes, etc. from industrial operations. B.T.U. values must be determined by the individual materials to be destroyed.

Type 6 — Solid by-product waste, such as rubber, plastics, wood waste, etc., from industrial operations. B.T.U. values must be determined by the individual materials to be destroyed.

CLASSIFICATION OF INCINERATORS

Class I — Portable, packaged, completely assembled, direct fed incinerators, having not over 5 cu. ft. storage capacity, or 25 lbs. per hour burning rate, suitable for Type 2 Waste.

Class IA — Portable, packaged or job assembled, direct fed incinerators 5 cu. ft. to 15 cu. ft. primary chamber volume; or a burning rate of 25 lbs. per hour up to, but not including, 100 lbs. per hour of Type 0, Type 1, or Type 2 Waste; or a burning rate of 25 lbs. per hour up to, but not including, 75 lbs. per hour of Type 3 Waste.

Class II — Flue-fed, single chamber incinerators with more than 2 sq. ft. burning area, for Type 2 Waste. This type of incinerator is served by one vertical flue functioning both as a chute for charging waste and to carry the products of combustion to atmosphere. This type of incinerator has been installed in apartment houses or multiple dwellings. (See notes on page 2B.)

Class IIA — Chute-fed multiple chamber incinerators, for apartment buildings with more than 2 sq. ft. burning area, suitable for Type 1 or Type 2 Waste. (Not recommended for industrial installations.) This type of incinerator is served by a vertical chute for charging wastes from two or more floors above the incinerator and a separate flue for carrying the products of combustion to atmosphere.

Class III — Direct fed incinerators with a burning rate of 100 lbs. per hour and over, suitable for Type 0, Type 1 or Type 2 Waste.

Class IV — Direct fed incinerators with a burning rate of 75 lbs. per hour or over, suitable for Type 3 Waste.

Class V — Municipal incinerators suitable for Type 0, Type 1, Type 2, or Type 3 Wastes, or a combination of all four wastes, and are rated in tons per hour or tons per 24 hours.

Class VI — Crematory and pathological incinerators, suitable for Type 4 Waste.

Class VII — Incinerators designed for specific by-product wastes, Type 5 or Type 6.

Standards of the Incinerator Institute of America

APPENDIX E
Incinerators Meeting Emission Standards as Specified in the Code of Federal Regulations (42CFR76) for Federal Activities*

Name: Disposacon
Manufacturer: Automated Disposal Systems, Inc.
1401 Ellsworth Industrial Blvd.
P.O. Box 19858
Atlanta, Georgia 30325
Model: 666 with the HWH-19 waste charger
Rate: 330 lb/hr of Type 1 waste

Name: Wasteco
Manufacturer: Wasteco, Inc.
17825 S.W. Pacific Highway
Sherwood, Oregon 97140
Model: SCR-450 multiple chamber incinerator and S-500 scrubber and induced-draft fan
Rate: 300 lb/hr of Type 1 waste

Name: Smokatrol
Manufacturer: Smokatrol, Inc.
66th & Pulaski Highway
Baltimore, Maryland 21237
Model: AB 600 Security
Rate: 318 lb/hr
Comments: Afterburner input--600 Btu/lb waste

Name: Consumat
Manufacturer: Waste Combustion Corporation
P.O. Box 6295
Richmond, Virginia 23230
Model: V-75, V-18, V-32, V-130, H-125, H-200, H-325, H-760

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*Current as of 3-23-71.

Rate: Maximum Burning Rate lb/hr

Type Waste	V-18	V-32	V-75	V-130	H-125	H-200	H-325	H-760*
0	75	140	300	465	555	795	1,050	1,650
1	75	140	300	465	555	795	1,050	2,100
2	55	110	230	355	425	615	320	2,900

Comments: Must have a collar around the stack above the afterburner that induces air into the stack. Both a primary burner and an afterburner are required.

*Model H-760 is also manufactured by Waste Control Systems, Inc., 3700 Greenway Plaza, Houston, Texas 77027

Name: Combustall
Manufacturer: Air Preheater Company
Wellsville, New York 14895
Model: 200, 400, 600, 800, 1,000, 1,200
Rate: Maximum Burning Rate lb/hr

Type Waste	200	400	600	800	1,000	1,200
0	150	300	450	600	750	900
1	200	400	600	800	1,000	1,200
2*	300	550	775	1,000	1,250	1,600

*Auxiliary Burner Required Btu/hr as follows:
1,000 300 400 500 600 700

Comments: Mechanical loader required for model 800 and larger

Name: Radicator

Manufacturer: Midland--Ross Corporation
P.O. Box 751
New Brunswick, New Jersey 08903

Model: Mark VI, XV, XX

Rate:

Type Waste	Maximum Burning Rate lb/hr VI	XV	XX
0	445	1,070	1,425
1	625	1,500	1,910
2	795	1,910	2,540

Comments: The Mark XV and XX are equipped with mechanical loaders and are fired with either gas or light oil

Name: Comtro

Manufacturer: Comtro, Inc.
North Wales, Pennsylvania 19454

Model: A-20

Rate: 160 lb/hr of Type 1 waste

Name: Joseph Goder

Manufacturer: Joseph Goder Incinerators
2483 Greenleaf Avenue
Elk Grove Village, Illinois 60007

Model & Rate:

Model	Burning Rate (lb/hr)	Scrubber
1301	50	none
1311	100	none
1331	250	Model C*
1341	350	Model D*
1361	550	Model E*

*Joseph Goder Hydro Cyclo Scrubbers

Name:	Federal Enterprises
Manufacturer:	Federal Enterprises, Inc. 2800 W. Battlefield Road Springfield, Missouri 65804
Model & Rate:	Maximum Burning Rate lb/hr

	FE-1	FE-2	FE-3	FE-5
Type 0	55	70	110	187
Type 1	70	90	140	245
Type 2	110	135	210	370
Burner Sizes Btu/hr	150,000	200,000	250,000	350,000

	FE-8	FE-10	FE-12	FE-15
Type 0	280	400	600	740
Type 1	370	520	780	970
Type 2	560	780	1,180	1,450
Burner Sizes Btu/hr	450,000	600,000	750,000	900,000

Comments: All models shall have nameplates which list the capacity. Mechanical loaders will be necessary for the larger models.

APPENDIX F
PERFORMANCE SPECIFICATION FOR A PNEUMATIC SOLID WASTE SYSTEM

OPERATION BREAKTHROUGH

Prepared by

Office of the Assistant Secretary
for Research and Technology
Department of Housing and Urban Development
Washington, D.C. 20410

March 12, 1971

1 OBJECTIVE

The contractor shall design a system to provide for pneumatic solid waste collection services for the HUD BREAKTHROUGH site at____________. The system shall consist of the interface with vertical solid waste chutes, the loading stations, the collector conduits, the pneumatic equipment, the central collection station or stations, and the necessary control devices. The system may be the subject of a field study, after acceptance, to explore its performance with respect to economy, effectiveness, technical design, reliability, versatility, maintainability, noise environmental factors, safety, and occupants' acceptance. To prepare for the field study, the system must be designed to incorporate or provide for the attachment of certain instruments and transducers, which will be further specified and described by HUD during the design process.

DEFINITIONS

For the purpose of this specification, the pneumatic solid waste system shall consist of components capable of accepting site and occupant generated solid waste and transporting the waste pneumatically to a central collection station or stations. The structure to house the equipment and the storage area for the solid waste may be designed by others, but in all cases will conform to the criteria covered by this specification.

2.1 Vertical solid waste chute:

The interface between the vertical chute and the pneumatic system in all cases is covered by this specification and includes the appropriate devices to provide controlled admission of solid waste to the main pneumatic system and isolation of that vertical chute from the main pneumatic piping. The vertical solid waste chute may, in some instances, be designed by others to specifications provided by the PTC contractor. These specifications should include, as a minimum, the following requirements: The vertical chute interior shall be free of all protrusions which could trap material deposited therein. If a circular chute is employed, the ID of the chute shall not exceed the inside diameter of the main pneumatic line into which it feeds. In the event a square or rectangular shape is employed, the ID diagonal dimension shall not exceed the ID of the pneumatic line. Provision for attaching the chute to the PTC system shall be specified by the PTC contractor.

The maximum dimension (diameter or diagonal measurement) of the charging hopper, provided as part of the chute, to receive trash, shall not exceed the minimum cross sectional dimension of the chute to which it is immediately connected.

2.2 Loading station:

The station will receive, temporarily store, and dispatch solid waste. Loading stations are not part of a vertical chute sub-system and may service residents of individual dwelling units or a number of dwelling units. In certain cases, stations may be limited to access or actuation by service personnel only.

2.3 Collector conduit:

The collector conduit (pneumatic transport tube) will transport the waste from termination of chute or loading station to central collection station.

2.4 Pneumatic equipment:

The pneumatic equipment will provide necessary vacuum or air flow on the collector conduit to transport the solid waste to the central collection station and provide compressed air for valve actuation if required.

2.5 Central collection station:

The central collection station will receive the waste from the collector conduit and discharge it to other processing. It will also remove all air-borne debris from the system and provide final filtration and biological treatment as may be required before exhausting the conveying air to the outside atmosphere.

2.6 Control system:

Control devices will monitor the pneumatic system, provide automatic cycles, provide shut-off capability and comply with the other design parameters given. The control system will be compatible with the energy and other mechanical systems available.

2.7 Structures:

The structures shall comprise the buildings for enclosing the solid waste system; the chimneys or stacks for exhaust of air; and the structures, shields, materials, and landscaping required to provide acoustical control, air pollution control, odor control, limitations on magnetic interference, and visual privacy as further specified herein.

3 ECONOMICS

Within the limits imposed by the following sections of this specification covering Design Requirements, Future Expansion, Integration of Service Systems, and Quality Assurance, the pneumatic solid waste collection plant shall be designed for minimum cost of waste service to the users based on Present Value Techniques employing a discount rate of ten percent and a lifetime of 40 years for the plant.

4 DESIGN REQUIREMENTS

4.1 Calculation of design loads:

The system will be designed to accept loading at an assigned rate per dwelling unit, consisting of household solid wastes, commercial solid wastes, and yard wastes. Assigned loading rate will be calculated using known statistical averages in the applicable community. Adequate factors to cover peak load days and projected periodic future increase in waste generation will be considered in calculations.

4.1.1 Individual sub-system components will be based on the assigned loading rate, the assumed probable types and the maximum size and mass of the generated waste. The system shall be capable of accepting and transporting waste of sizes which will physically enter it and having a mass not exceeding 50 pounds per cubic foot.

4.1.2 Waste materials may be loose or containerized when initially placed in the system.

4.1.3 Multifamily, multistory buildings will be served by centrally located chutes or by individual unit loading stations. Low-rise single family attached structures and garden type units will be served by individual or shared loading stations.

4.2 Equipment selection:

4.2.1 Chute interface:

The chute-pneumatic transport and tube interface shall be size compatible with the chute as described in paragraphs 2.1 and 2.2 and shall provide for resistance to impact of waste falling free in the chute.

The interface will provide for intermediate retention of waste and include the devices for controlled admission of the solid waste to the collector conduit.

Provision shall be made at the interface to provide for disposition of liquids such as wash or fire sprinkler water entering the chute. Alternate designs incorporating chutes as an integral part of the system may be a desirable adaptation for some projects.

Methods to lock charging hoppers immediately before cycling the chute shall be considered in the design.

4.2.2 Loading stations:

Loading stations shall be designed for maximum occupant safety. Provision shall be made for adequate instructional signs, interlocks to prevent station operation when outer door is open, absence of sharp projections and accessibility for misdeposited articles. To deter access and operation of the station by small children, the outer door or the operating device for the outer door shall be located a minimum of 4 feet 6 inches from finished floors.

The loading stations shall provide for intermediate retention of waste and include devices for controlled admission of the solid waste to the collector conduit.

4.2.3 Collector conduit:

The collector conduit shall be designed with consideration being given to loading, air velocity and pressure, erosion from the transported waste, corrosion (internal and external) initial cost, replacement cost, soil conditions, cleanability, and other parameters affecting operation and service life.

In collector conduit layout, access shall be provided for all bends in the horizontal plane and intermediate access to the interior of long runs at intervals not to exceed the capability of readily available inspection and cleaning equipment, but not to exceed 400 feet.

The main pneumatic transport tube and branch lines shall be designed so that, in proceeding toward the central collection station, the inside diameter of the tube shall remain constant or increase.

Bends in the pneumatic tubing, drop T's, etc., shall have a minimum radius of curvature of 5 times the pipe diameter. Acceptable methods of connecting pipe sections include bolted flanges and welded flanges. For underground installation, welding is the only acceptable method.

The transport tube wall thickness selected for the system life, shall be supported by experimental data pertaining to erosion and corrosion.

4.2.4 Pneumatic equipment:

The exhausters shall be designed to provide flow of air at no less than 60 mph, and to maintain a vacuum sufficient in the system to transport solid wastes defined in paragraph 4.1. Support final designs with calculations, source of empirical or rational formulas used and other back-up data as required to enable HUD to perform a detailed technical evaluation.

The pneumatic equipment is to be compatible in voltage, phase, and other electrical characteristics with the availability energy system. Motors furnished will be constructed according to NEMA standards, Class B insulation with a maximum 80 C average rise above ambient and a 10 C hot spot allowance. Low current starting shall be employed. If pneumatic actuators are employed, plant air or a separate compressor system may be employed.

4.2.5 Central collection station:

The collection hopper shall provide for deceleration of the conveying air to achieve maximum fallout of loose waste. Automatic cleaning of the internal screen shall be provided in addition to automatic cleaning of the final filters.

The collection station shall be designed to provide for cleaning of discharge air with the efficiency specified in paragraph 4.6. Cleaning and filtering devices will be easily accessible for maintenance.

The collection station shall be designed for compatibility with subsequent processing methods and local waste handling service. and the collection station air discharge end point shall be compatible with specific site restrictions.

4.2.6 Operating and safety controls:

A. General:

1) Operating controls may be designed for pneumatic, hydraulic, or electrically driven actuators. Justification for selection shall be prepared by contractor.

2) The system shall be designed for automatic operation.

3) The pneumatic system should be programmed in the following manner:

   a) Start blowers.

   b) Open air inlet or branch nearest to collection station.

   c) Cycle trash discharge valves as in 4) below.

After the valves in a branch have been cycled, air flow should be maintained for a period of time to insure that all trash has been removed from the line. The cycle time estimate should be supported by detailed analyses, and provision made for adjusting the cycle time during the check-out phase. Consideration should be given to incorporating instrumentation to indicate line cleanliness.

4) In establishing the sequence of admitting solid wastes to the main pneumatic transport tube, the branch line closest to the collection hopper shall be activated first. The valve closest to the main pneumatic transport line on that branch shall be activated, and that branch completely cycled (moving from the

closest in, to that valve nearest the air intake) before moving on to the next branch away from the collection station.

5) Control signals (to and from main panel) and instrumentation readouts can utilize hard wire or multiplex. Justification for selection of one must be prepared by the contractor.

6) Operating instrumentation shall include, but not be limited to:
   - a) Air flow prior to hopper--low reading will shut down system.
   - b) Pressure drop across hopper screen--high pressure drop will activate screen cleaning procedures.
   - c) Humidistat in main pneumatic line just prior to cyclone hopper referenced to outdoor humidistat. High moisture in

pneumatic transport tube will shut down the system.

d) Trash level sensors in chutes expected to encounter extraordinary conditions. Sensor will activate the system.

e) Valve position indicators.

f) Last valve actuated indicator.

g) Pressure drop at critical system points to aid in locating blockage.

7) Controls shall include automatic operation of self-cleaning screens and filters.

8) Provision should be made to obtain samples for biological analysis of discharge air.

9) Except for pressure loss, fire, or other safety features, design controls to provide for manual overrride.

10) Additional operating and control functional parameters are specified in paragraph 4.3 System Reliability and paragraph 4.10 Safety Requirements.

B. Chute system:

If valve fails to close, provision is to be made to cycle that valve an additional two times (if necessary) before going on to next valve. If a chute discharge valve does not operate after three attempts, the entire system shall be shut down until valve is serviced.

C. Individual loading stations:

Triple actuation as in B above shall be incorporated; however, if valve fails to close after third time, this event shall appear on annunciator panel, appropriate events sequenced to obtain maintenance, but system shall continue to operate going to next valve.

4.3 System reliability:

4.3.1 Provide sufficient pneumatic equipment redundancy so that the failure of any one unit will not cause the shutdown of the entire solid waste system and so that planned overhaul of each unit of pneumatic equipment can be accomplished without jeopardizing the ability of the system to transport the solid waste. Provide a justification for the number of pneumatic units selected for the system.

4.3.2 The pneumatic equipment, motors, load dispatching devices, air cleaning devices and control devices shall be designed for high reliability, supported by maintenance instructions directed towards this end, such that interruptions to solid waste collection service shall not exceed a frequency of one interruption per month on the average, and no single interruption of service shall exceed 24 hours duration.

4.3.3 The solid waste system shall be designed for automatic operation of the pneumatic units, load dispatching devices and the discharge-air cleaning devices. Equip each pneumatic unit, load dispatching device, discharge air cleaning device with instruments and relays that will sense abnormal conditions of load, pressure, temperature or other parameter that could permanently damage a unit, the plant, or personnel or interrupt solid waste service; that will automatically shut down the affected unit and transmit a signal to start an alternate unit; and will provide, at a location to be designated, visible and audible signals indicating a distress condition. Coordinate signaling systems with the management concept of the site developer. Coordinate the instrumentation for sensing distress conditions with the instruments to be installed for long-term study of the system operation by the appropriate Government agencies.

4.4 Maintenance requirements:

4.4.1 Design all mechanical and electrical equipment, blowers, compressors, motors, etc., so all removable parts can be renewed or replaced on site during major overhauls such that the performance can be restored to essentially that of new equipment without removing the chassis from the plant.

4.4.2 Design all mechanical and electrical equipment to operate at least 15,000 calendar hours between major overhaul periods.

4.5 Noise and vibration control requirements:

4.5.1 With all equipment operating that is required to meet maximum design load, air-borne noise generated by the pneumatic solid waste collection plant shall not exceed ________________* at any of the following locations:

A. At any window or door opening in the walls of occupied buildings directly visible from the pneumatic solid waste collection plant, throughout the height of the occupied building, measured three feet outside the wall surface.

B. Within the boundaries of any outdoor

*Site specific condition

recreation area or other regularly occupied outdoor area in the zone surrounding the pneumatic solid waste collection plant, measured five feet above the immediate surface.

C. Along the boundary line between the Breakthrough site and all adjacent property, measured five feet above ground level.

The reference ambient sound pressure level at these stations shall be determined by site noise surveys conducted by the National Bureau of Standards before and after construction on the site is completed.

4.5.2 Any common wall, floor, or ceiling between the pneumatic solid waste collection plant and adjoining occupied spaces shall have a sound transmission loss sufficient to meet the NC levels specified in the Guide Criteria for the Design and Evaluation of Breakthrough Housing and in Chapter 20 of the book "Noise Reduction", edited by L.L. Beranek, McGraw-Hill 1960, referenced therein.

4.5.3 Operation and maintenance personnel required to work in the pneumatic solid waste collection plant shall be protected against exposure to noise in excess of the limits specified in the Walsh Healy Act. The required acoustic environment may be attained by selection of equipment, by acoustical treatment of equipment and enclosures, by providing adequate protective devices for the personnel, or by a combination of these techniques.

A. The noise level in the area of the pneumatic solid waste collection plant occupied by the control systems and instrumentation panels shall not exceed 70 dBA when all of the mechanical equipment required to handle the maximum load is in operation in order to promote reliability of voice communication between operating personnel. Acoustically protected areas of booth size are not considered adequate to meet this requirement.

B. In order to promote reliability of communication, and the safety and health of operating and maintenance personnel, the noise level in the areas of the pneumatic solid waste collection plant where two or more personnel must cooperate in carrying out regularly assigned operating or maintenance duties shall be controlled at 85 dBA or lower by permanent or portable acoustical treatment.

4.5.4 All rotating and reciprocating equipment shall be mounted on vibration isolators providing a minimum isolation efficiency of 85 percent at a frequency corresponding to the design speed of the equipment for this plant.

4.5.5 Metal piping connected to power-driven equipment shall be resiliently supported from or on the building structure for a distance of 50 pipe diameters from the power-driven equipment. The resilient isolators shall provide a minimum isolation efficiency of 85 percent at a frequency corresponding to the design speed of the equipment for this plant.

4.5.6 Vibration eliminators shall be used to connect rotating machinery to pipe and duct systems.

4.6 Air pollution control:

4.6.1 The amount of particulate matter in the system exhaust shall meet the air pollution limitations contained in the Federal Regulations and Amendments issued by the Department of Housing and Urban Development pursuant to Executive Order 11282, "Prevention, Control, and Abatement of Air Pollution by Federal Activities", or the local codes whichever is more stringent. Bacteria count in the system exhaust shall not increase the normal background level as determined by the appropriate Government agency.

4.6.2 The ventilation air from the equipment room, and the exhaust air from the system shall not be discharged directly toward any nearby building, recreation area, or other occupied space, and shall not result in offensive odors, detectable by sense of smell, in any regularly occupied building or recreation area, or in any regularly used thoroughfare. Any moist air from the system shall not create visible fog nor produce detectable mist or frost in recreation or traffic areas. The air in the central collection room shall be filtered to remove particulate matter and odor prior to discharge to the surroundings.

4.6.3 Any exhaust stack used to discharge exhaust air shall comply with the requirements of the local building code.

4.6.4 The exhaust air from the pneumatic solid waste collection plant shall not impinge upon or envelop any door, window, air intake opening, outdoor recreation area or other regularly occupied outdoor space for wind velocities in the range from 0-15 miles per hour from any direction as determined by tracer gas techniques or other methods.

4.7 Thermal environment and ventilation:

4.7.1 The air temperature at the five-foot level in all enclosed spaces in the pneumatic solid waste collection plant that are utilized by operating or maintenance personnel shall be maintained in the range from 65 F to 90 F for the specified range of design outdoor conditions, by a combination of heating, air conditioning, and ventilating systems.

4.7.2 The pneumatic solid waste collection plant shall be ventilated with outdoor air to satisfy fresh air requirements for the equipment and maintenance personnel in the equipment rooms, offices, shops, and toilets.

4.8 Aesthetic requirements:

4.8.1 Provide architectural, landscaping, or other decorative treatment for plant stacks, air intake or discharge openings, exterior loading stations, and other exterior or rooftop auxiliaries that are in direct line of sight from ground level or window of an occupied building at a distance of 200 feet or less from the perimeter of the pneumatic solid waste collection plant.

4.8.2 Provide a scale model of the pneumatic solid waste collection plant; the architectural, landscaping, and decorative features identified above; and the pertinent nearby building exposures, along with the working drawings and specifications for visual evaluation of the aesthetic features of the design. A model of the interior of the plant shall be provided as a basis fee evaluation of equipment accessible for maintenance and replacement.

4.9 Illumination requirements:

Provide a level of illumination of 30 footcandles in the areas occupied by the mechanical and electrical equipment. Illuminate the front faces of vertical switchboards and control panels at a level of 30 footcandles in a manner that will prevent glare and reflections from meter faces and panels. Provide level of illumination on the rear of switchboard panels of at least 10 footcandles, and 20 footcandles in areas occupied by auxiliary equipment.

4.10 Safety requirements:

Design the pneumatic solid waste collection plant for an acceptable level of personnel safety, fire safety, equipment safety, and plant safety. Recognized standards pertaining to prevention of explosions, fires, floods, and unnecessary equipment failures are listed in the Appendix and form a part of this specification.

4.10.1 Explosions:

Each component in the pneumatic solid waste collection system shall be designed and constructed according to recognized national or industry standards and must comply with applicable local codes. Pressure or vacuum vessels and system piping shall be designed in accordance with the ASME Boiler and Pressure Vessel Code. All pressure vessels must be registered by the American Society of Mechanical Engineers and must have ASME numbers stamped on the outer shell. All pressure vessels shall be designed with ASME approved safety valves. System piping shall be designed according to good practice and ANSI standards.

4.10.2 Fires:

A central fire alarm system meeting the requirements of NFPA and local codes must be installed and connected to the alarm system for the entire site. All wiring and electrical components must comply with the National Electrical Code. Where applicable, the electrical components and systems must be UL approved and also comply with the local code.

4.10.3 Floods:

The pneumatic solid waste collection plant shall be designed to guard against flooding from either internal or external causes. Drainage systems and overflow features in the plant and utility areas must be sized to permit rapid drainage to prevent flooding of electrical components and mechanical equipment in the event of accidental breakage of water-containing systems.

Outside grading shall be designed to provide rapid run-off away from the plant under anticipated normal and abnormal rainfall conditions. Gravity run-off may be supplemented or replaced by an automatically-started sump pump system.

4.10.4 Equipment and operator safety:

Equipment shall be arranged and spaced for safe and effective operation, servicing, and repair. Maintenance of one piece of equipment should not endanger an adjacent piece of operating equipment or place the personnel in a dangerous position relative to other equipment. Rotating machinery, hot surfaces, sharp projections, components with low clearance, and operating levers of switches, relays, and safety devices shall be protected from accidental contact by operating and maintenance personnel.

4.11 Magnetic interference suppression:

Magnetic interference suppressors shall be provided for the commutators of motors and other electrical systems, controls, and apparatus, if needed to control interference with radio and television reception in the buildings on the Breakthrough site and the immediate vicinity.

4.12 Collector conduit:

The design of the pneumatic collection system shall use a minimum of above grade and visible components. The desigh of the pneumatic conduits shall utilize the procedures and criteria described in the District Heating Handbook, International District Heating Association, 1969, and in Underground Heat Distribution Systems BRAB-FCC Report 30R-64, with respect to expansion and contraction of pipes, methods of supports, protection of pipes from water and corrosion, for insulation requirements, and for mechanical protection of the conduits from surface loads or shifting earth.

5 FUTURE EXPANSION

The design of the pneumatic solid waste collection system shall be sized to accommodate a future increase in load of 25 percent.

6 INTEGRATION OF SERVICE SYSTEMS

6.1 If economy, performance, environmental quality, or space saving is enhanced thereby, the structures and distribution or collection systems for the energy system, the solid and liquid waste disposal systems, and any other service systems for the site shall be integrated in accordance with good engineering design.

6.2 The electrical demand schedule of the site shall be taken into account in determining the operating cycle in the pneumatic solid waste collection system.

6.3 Common or adjacent plant space shall be used for all centrally located service systems, if possible, and the methods used to control air pollution, noise, vibrations, odor, and undesirable aesthetic appearance shall be designed to serve the common needs of all service systems.

6.4 Annunciator panels, alarms, safety controls, etc., shall be designed to satisfy the requirements for all service systems, insofar as possible.

6.5 The design of the various service systems should facilitate joint use of operating and maintenance personnel.

7 QUALITY ASSURANCE

Assurance of compliance with the design and performance requirements of this specification will be provided by a combination of reviews of design procedures, plans, and specifications; pre-installation tests of components; examination of manufacturers' test data; inspection of equipment; certification and labelling of components and systems; and monitoring of acceptance tests at the time the plant is put into service. The quality assurance activities will be carried out by technical representatives of the Department of Housing and Urban Development and other organizations as directed by HUD. These quality assurance activities are further detailed as follows:

7.1 Adequacy of the load calculations; the calculations of monthly energy use; the aesthetic treatment of the plant components; and the required capacity of the principal system components will be determined by detailed review of the preliminary plans and the working drawings and specifications at prearranged stages in the design process.

7.2 Cost estimates for energy, capital equipment, and maintenance and operation will be reviewed by technical representatives of HUD and their designees. These estimates shall include the cost of final disposition of the solid wastes.

7.3 Test results obtained by the suppliers of major equipment components in their own laboratories will be reviewed for comparison with ratings and performance used in design. Prequalification tests will be requested if existing information is inadequate.

7.4 The design, performance test results, and national labelling and listing of instruments, controls, and relays designed for sensing abnormal operating conditions and as operating controls will be studied prior to installation. The performance of these devices will be observed during prequalification tests and/or during the acceptance tests of the plant.

7.5 The models of the equipment and storage rooms proposed for the installation will be studied in advance for maintainability, ease of repair, and potential for complete renewal.

7.6 Compliance with safety requirements will be determined by inspection, labelling, certification, and comparison of design with the requirements of safety standards.

7.7 The acceptance tests performed by the contractor on the site after the installation is completed will be monitored for completeness and for compliance with plans and specifications.

7.8 Tests for compliance with the performance requirements on noise and vibration control, air pollution control, ventilation, thermal environment, aesthetics, magnetic interference, and illumination will be performed during the acceptance tests of the plant or as soon thereafter as the necessary climatic and operating conditions occur. Corroborative tests may be made by HUD or their designees if required.

7.9 Long-term reliability and durability can be evaluated only during long-term field observations or tests. These aspects of the performance specification will not be covered by the acceptance tests.

7.10 Systems, equipment, or apparatus which do not comply with the details of this specification, but which perform in accordance with its intent, may be approved for installation by the Department of Housing and Urban Development.

Appendix
List of Standards Related to Fire, Safety, Explosions, and Protection against Equipment Failures

NFPA No. 54-1969 "Combustion Air and Ventilation".

NFPA No. 70-1968, ANSI C 1 - 1968 (Rev. of C 1 - 1965), "National Electrical Code".

NFPA No. 30-1969 "Flammable & Combustible Liquids Code".

NFPA No. 328-1964 "Flammable and Combustible Liquids and Gases in Manholes and Sewers".

NFPA No. 13-1969 "Installation of Sprinkler Systems".

NFPA No. 29-1969 "Installation of Centrifugal Fire Pumps"

NFPA No. 211-1969 "Chimneys, Fireplaces and Venting".

NFPA No. 12-1968 "Carbon Dioxide Extinguishing Systems".

NFPA No. 14-1969 "Installation of Standpipe and Hose Systems".

NFPA No. 15-1967 "Water Spray Fixed Systems for Fire Protection".

NFPA No. 26-1958 "Supervision of Valves Controlling Water Supplies for Fire Protection".

NFPA No. 291-1935 "Marking of Hydrants".

NFPA No. 71-1969 "Installation, Maintenance and Use of Central Station Protective Signalling Systems (Watchman, Fire Alarm and Supervisory Service)".

NFPA No. 72B-1967 "Installation, Maintenance and Use of Auxiliary Protective Signalling Systems for Fire Alarm Service".

ASME Boiler and Pressure Vessel Code - 1965 (amendments to 1969). Section IV, Heating Boilers (1966).

ASME Boiler and Pressure Vessel Code - 1965 (amendments to 1969). Section VIII, Unfired Pressure Vessels (1965).

ANSI Standard Safety Code for Mechanical Refrigeration, B 9.1 1969.

ANSI National Electric Safety Code, Part I, Rules for the Installation and Maintenance of Electric Supply Stations and Equipment (1970).

ASHRAE No. 52-68 Method of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

INFLUENCE MATRIX FOR PNEUMATIC SOLID WASTE SYSTEM
DESIGN PROCUREMENT SPECIFICATIONS

SYSTEMS FACTORS - SUB-SYSTEMS	FUNCTION					SAFETY					ENVIRONMENTAL					OTHER					
	Operability Operation Constraints	Useful Life	Durability/ Time Reliability	Maintainability	Performance Characteristics Primary - Secondary	Occupant	Operator	Fire	Structural	Property Damage	Odor	Air Pollution	Noise	Vibration	Occupant Acceptance	Economic Factors	Transportability	Enclosure Restrictions	Final Waste Disposition Method	Oversize Material	
Interface Waste System - Energy Source	4.2.4				4.2.4	4.10.4	4.10.4	4.10.2								6.2					
Interface Waste System - Chute	4.2.1	3.0	4.3.1	4.4.1	4.2.1		4.2.6	4.10.2	4.2.1	4.2.1	4.6.2		4.5.6		4.2.1					4.1.1	
Interface Waste System - Occupant	4.2.2	3.0	4.3.1	4.4.1	4.2.2	4.2.2	4.2.2	4.10.2		4.2.2	4.6.2		4.5.3		4.2.2					4.1.1	
Interface Discharge Air - Site	4.2.5	3.0	4.3.2		4.2.5	4.6.4		4.10.2			4.6.2	4.6.1	4.5.1					4.8			
Pneumatic Equipment	4.8.2 4.2.4	4.2.4	4.3.1	4.4.1	4.2.4		4.10.4	4.10.2	4.5.4		4.6.2	4.6.2	4.5.1	4.5.4		3.0	4.4.1	4.8		4.1.1	
Collector Conduit	4.2.3	4.2.3	4.2.3	4.2.3	4.2.3	4.2.3	4.2.3	4.10.2	4.2.3	4.2.3	4.6.2		4.5.6	4.5.5		4.2.5					
Collection Station	4.2.5	3.0	4.3.2	4.2.5	4.2.5		4.12.4	4.10.2	4.2.5	4.2.5	4.6.2	4.6.1	4.5.1	4.5.4				4.8	4.2.5		
Operating Controls	4.2.6	3.0	4.3.3	4.4.2	4.2.6	4.2.6	4.9 4.10.4	4.3.3								6.4		4.8			
Safety Controls	4.2.6	3.0	4.3.3	4.4.2	4.2.6	4.2.6	4.10.4	4.3.3		4.2.6						6.4					
Structural Characteristics		3.0					4.7.2	4.10.2	4.12			4.6.3	4.5.2	4.5.2				4.8			
Interface Waste System - HSP	4.1				4.1	4.12		4.10.2							4.2.2	3.0		4.8	4.2.5		

APPENDIX G
PERFORMANCE SPECIFICATIONS FOR STATIONARY SOLID WASTE COMPACTORS

OPERATION BREAKTHROUGH

ENVIRONMENTAL PROTECTION AGENCY
Solid Waste Management Office
March 1971

1 OBJECTIVE

Several types and sizes of stationary compactors for solid waste are to be selected for some of the HUD Operation Breakthrough housing sites. They must be capable of satisfactorily compacting and storing solid waste generated by residential, commercial, and institutional facilities located on the sites according to the requirements specified herein.

2 DEFINITIONS

2.1 Stationary solid waste compactor: A machine that reduces the volume of loose solid waste by not less than two-thirds by means of mechanical force, and which places the waste into a container for storage.

2.2 Containers: The receiving unit into which the compacted solid waste is placed by the compactor. A container is either returnable or disposable, and will be evaluated with its compactor as a system.

2.3 Normal residential solid waste: All items normally discarded as refuse at a household, excluding bulky items that will not fit into a 30-gal waste container. This includes a wide variety of items of the following approximate composition given as a percent by wet weight of each component with ranges at the 90 percent confidence interval:

Component	Mean (%)	Range (%)
food waste	18	11 - 22
paper products	44	38 - 49
metals	9	8 - 10
glass and ceramics	9	7 - 10
plastics and rubber	3	2 - 4
textiles	3	1 - 3
wood	2	1 - 3
garden waste	8	2 - 9
rocks, dirt, ash, etc.	4	1 - 5

It is expected that the composition of residential solid waste generated at Operation Breakthrough sites will be within the ranges given above. In addition, normal residential solid waste may be expected to contain about 25 percent moisture and have an average density of about 170 lb per cu yd.

3 SPECIFIC REQUIREMENTS

3.1 Stationary solid waste compactors for residential applications in Operation Breakthrough shall be capable of compacting normal residential solid waste by at least two-thirds its original volume. Compactors for commercial and other applications shall be capable of compacting the specific type of waste to be encountered by not less than two-thirds its original volume. These capabilities shall be verified by certified test data or actual observed tests as directed by HUD or its representative.

3.2 The capacity of a compactor system shall be determined for each installation, based upon the cost of the equipment and the cost of servicing at the frequency required by the amount and type of waste to be handled.

3.3 A compactor used for solid waste which contains by weight more than 40 percent moisture, or more than 30 percent food waste, shall be specially designed to accept and retain moisture set free during the compaction process. The liquid shall either be retained in the container or drained by direct connection to a sanitary sewer.

3.4 Manually-fed compactors shall have self-closing doors which adequately seal the entrance when the doors are shut, so that access by rodents and insects is precluded, and interior odors are not transmitted to the ambient air. Chute-fed compactors shall be attached to the chutes in a manner that similarly seals the connection between them. Although not a part of the compactor, the chute should also be equipped with self-closing, well sealed access doors.

3.5 Exterior exposed surfaces and interior surfaces which come in contact with solid waste shall be readily cleanable without the need for special tools or dismantling. Adequate clearance is also required for cleaning underneath the compactor unless the compactor bottom is sealed and is designed to be set flat on the floor.

3.6 Chute-fed compactors shall have a suitably by-pass on the inlet side of the compactor to permit hand removal of solid waste in case of system failure.

3.7 Chute-fed compactors shall have a suitable shut-off gate of sufficient strength to withstand the impact of the maximum size package that could enter the system, of 50 lb/cu ft density, falling from the maximum chute elevation, to retain solid waste in the chute to allow for proper maintenance and safety. This gate shall close automatically when access is made possible to the interior of the compactor.

3.8 Other suitable safety devices shall be provided and additional devices may be required at the direction of HUD or its representative.

3.9 Chute-fed compactors shall be automatically actuated to avoid accumulation of solid waste in the chutes.

3.10 Chute-fed compactors shall have adequate sensing devices to alert maintenance personnel when they need attention either for normal servicing or because of malfunction.

3.11 Adjustments affecting the output density of the solid waste shall be pre-set and not controllable by the operator.

3.12 Returnable containers must be capable of withstanding compaction pressures without deforming, and of easily discharging the compacted solid waste by gravity; and shall be readily cleanable.

3.13 Disposable containers shall not break or tear during compaction and normal handling.

3.14 All containers shall be fly-tight and moisture proof while either attached to the compactor or removed for storage.

3.15 Both compactor and container shall be so designed that spillage of waste does not occur when the filled container is removed from the compactor.

3.16 Each compactor shall have an identification plate attached to it identifying the manufacturer, model, serial number, and power requirements.

3.17 A maintenance manual shall be provided to the purchaser of each compactor. A copy of the manual shall also be provided to HUD or its representative. The maintenance manual should include the following information:

- 3.17.1 Periodic cleaning, maintenance and lubrication chart.
- 3.17.2 Parts list and labeled drawings.
- 3.17.3 Trouble shooting procedure.
- 3.17.4 Electric circuit diagram.
- 3.17.5 Hydraulic circuit diagram, if applicable.
- 3.17.6 Description of sequence of operation.
- 3.17.7 Name, address, and telephone number of the authorized repair and parts source.
- 3.17.8 All other necessary items.

4 GENERAL REQUIREMENTS

4.1 All local codes and ordinances shall be adhered to except where they conflict with these specifications, in which case the conflicts shall be resolved by HUD or its representative.

4.2 The size, shape, weight, and density of the compacted solid waste including the container or binding, if used, shall be compatible with locally available collection and disposal services.

4.3 Prior to the purchase of a solid waste compactor for Operation Breakthrough, the seller shall provide the following items to HUD or its representative:

4.3.1 A description of the criteria used in selecting the proposed compactor model, including analysis of the waste to be compacted, design calculations, and assumptions.

4.3.2 A complete description of the proposed compactor model including literature, photographs, dimensional drawings, electric and hydraulic circuit diagrams, technical specifications, and operating and maintenance manuals.

4.3.3 The list price of the proposed compactor model and estimated operating costs with a description of the basis for this estimation.

4.3.4 A complete parts list including any special tools needed for maintenance with part numbers, prices, and source.

4.3.5 Certified test data as described in paragraph 3.1 of these specifications.

4.3.6 A certified letter which states that:

A. A minimum warranty of one year for all components of the system shall be provided and any service or parts required under the warranty shall be provided within 24 hours during the warranty period, at no charge.

B. Service and parts will be available within 24 hours during the expected life of the compactor and the name, address, and telephone number of the nearest service station shall be included. Present nominal charges for service calls and labor, or for a service contract, shall be included.

4.3.7 The names and addresses of the solid waste collection and disposal agencies or companies that are capable of handling the compacted solid waste, the level of service available, and the expected charges. (The waste should be removed for disposal at least once a week).

4.3.8 A document which clearly establishes the responsibility of regular cleaning and maintenance of returnable containers, if used, and which indicates acceptance of this responsibility by the appropriate party.

5 INSTALLATION REQUIREMENTS

The purchaser of a compactor shall be responsible for proper installation as described in these requirements.

5.1 Hot water of at least 140 F, in sufficient quantities, shall be made available to all compactors for cleaning purposes. Compactors of greater than 1/2 cu yd capacity (final compacted package) and all chute-fed compactors shall have this hot water piped to as close as practicable to the compactor with a hose connection provided.

5.2 All compactors shall be placed on Portland cement concrete or other satisfactorily finished floors that can be easily cleaned.

5.3 Compactors greater than 1/2 cu yd in capacity (final compacted package), and all chute-fed compactors, shall be served by floor drains connected to sanitary sewers for draining all water used in washing the compactors and their containers. Such drains shall be properly screened and protected from rain-water runoff by adequate shelter and curbing. The drains shall be readily accessible for cleaning and shall not be located under the compactor or container.

5.4 Compactors which use returnable containers shall be installed with adequate guides for the containers to assure proper alignment when being re-attached. Steel plates shall be installed in areas where rolling of large containers can cause excessive wear on the floor. Where wheeled containers must be rolled through a corridor or other confined space in a building, adequate guides shall be provided to eliminate damage to the structure by mishandling of the containers.

5.5 When compactors are installed in enclosed spaces, the air temperature at the five-foot level shall be maintained in the range of 65 F to 90 F and ventilation of at least 20 cu ft per min of fresh air shall be provided.

5.6 The noise level in the area of a compactor shall not exceed 70 dBA when the equipment is operating at maximum load.

5.7 Illumination at a level of at least 30 footcandles shall be provided at all points that require access by compactor operating and maintenance personnel; and on the faces of switchboards and control panels. All other areas around the compactor shall be illuminated at 10 footcandles measured 3 feet above the floor.

5.8 The compactor installation shall be designed for an acceptable level of personnel safety, fire safety, and equipment safety.

5.8.1 Each component of the compactor system shall be designed and constructed according to recognized national or industry safety standards and must comply with applicable codes. Pressure and vacuum vessels and piping shall be designed in accordance with the ASME Boiler and Pressure Vessel Code and shall be provided with ASME approved safety valves.

5.8.2 A compactor greater than 1/2 cu yd in capacity (final compacted package) and which is located within a structure or closely adjacent to a structure or to any combustible material shall have a fire alarm which meets the requirements of NFPA and local codes.

5.8.3 All wiring and electrical components shall comply with the National Electrical Code and, where applicable, be UL approved and comply with local codes.

5.8.4 Compactor installations shall be designed to guard against flooding of electrical or mechanical equipment from either internal or external causes. Outside installations shall provide for rapid run-off and drainage of rainfall.

5.8.5 Compactors shall be installed for safe and effective operation, servicing, and repair. Maintenance of a compactor or other nearby equipment should not endanger an adjacent piece of operating equipment or place the personnel in a dangerous position relative to other equipment. Rotating machinery, hot surfaces, sharp projections, objects with low clearance and operating levers of switches, relays and safety devices shall be protected from accidental contact by operating and maintenance personnel; and shall be protected from unauthorized access.

5.8.6 Loading openings for compactors in residential applications shall be no higher than 4 ft 6 in. above the floor to provide for a safe loading height and shall be designed to deter access by small children. In commercial and other applications where stairs and platforms are required, they shall be fitted with suitable railings, non-skid treads and other necessary safety devices.

5.9 Magnetic interference suppressors shall be provided for the commutators of motors and other electrical apparatus, if needed to control interference with radio and television reception in the immediate vicinity.

6 TESTING

These procedures shall be followed if pre-purchase testing of a solid waste compactor is judged to be necessary by HUD or its representative. These procedures may also be used after installation to determine the acceptability of a compactor.

6.1 Tests may be performed either at an operating installation or a pilot installation.

6.2 Input material for testing compactors for residential applications shall be normal residential solid waste with a loose density range of 150 to 230 lb per cu yd which shall be determined before compaction. For compactors to be installed in other than residential applications, the type of material to be compacted in normal operation shall be used for the tests.

6.3 The density of the compacted solid waste shall be determined and shall fall within the range of 450 to 700 lb per cu yd corresponding to at least three times the input density.

6.4 The compactors shall be loaded continually during the tests until they reach their capacity.

6.5 Chute-fed compactors shall be fed through a chamber of at least 3 cu ft capacity and shall operate under a continuous head of solid waste.

6.6 HUD or its representative shall provide a test engineer who will help conduct the tests, record the data and determine the number of trials required to complete the tests.

6.7 The seller shall provide the necessary laborers and mechanical personnel and equipment required to conduct the tests, and shall be responsible for expenses incurred during the test.

6.8 Failure to meet the required density of compacted solid waste; malfunction of equipment; breaking, tearing, or leaking of containers; or other significant faults shall be grounds for disapproval of the compactor.

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